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MEMORY ORGANIZATION-BASED METHODS OF INSTRUCTION:  
A COMPARISON WITH PERFORMANCE-ORIENTED TRAINING

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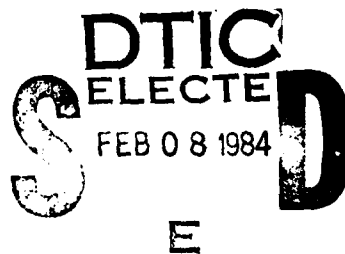
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the structure information. Under the constraint that these alternative training programs should not cost extra training time, they did not improve learning over the Army's standard performance oriented training strategy. Discussion concerned the role of practice and student ability in the acquisition of memory organization during learning.

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MEMORY ORGANIZATION-BASED METHODS OF INSTRUCTION:  
A COMPARISON WITH PERFORMANCE ORIENTED TRAINING

EXECUTIVE SUMMARY

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Requirement:

The Army's standard method of training, performance oriented training (POT), has guided the development of Army training programs for ten years. In that time, a number of advances have been made in theoretical cognitive or information-processing psychology which have implications for training design. Training strategies based on this theoretical background were tested in this research.

Procedure:

Training was designed to provide students organizing structures for four armor crewman tasks. This task structure information was added to POT in two alternative formats: one in which the structure guided presentation and practice from the beginning of training (called top-down) and one in which students were first allowed to have hands-on exposure to the task before being given the structure information (called bottom-up). These two strategies were tested against the basic POT strategy. Three groups of 19 soldiers each were taught the four tasks by one of the three training strategies. They were tested two days following training.

Findings:

In general, the presentation of task structure information did not affect learning or recall except to the extent that it reduced the amount of time available for practice. However, three of the four tasks were so easy that probably no alteration of POT could have improved performance. For the fourth and most difficult task, performance was dependent on training strategy only to the extent that top-down students received fewer practice trials, and thus did not progress as far on the trial-by-trial acquisition curve which appeared to be the same for all three groups. Evidence was found that regardless of training condition, students begin to structure their memory for the task on their own and immediately at the beginning of instruction.

Utilization of Findings:

This research offers a basis for continued investigation of the application of cognitive, information-processing theory to training. In particular, two issues were identified which call for refinement in the approach. First, greater attention should be given to the selection of tasks for which providing assistance in the organization of task steps would be fruitful. Second, greater attention should be given to the subjective organization strategies of the student.

MEMORY ORGANIZATION-BASED METHODS OF INSTRUCTION:  
A COMPARISON WITH PERFORMANCE ORIENTED TRAINING

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MEMORY ORGANIZATION-BASED METHODS OF INSTRUCTION:  
A COMPARISON WITH PERFORMANCE-ORIENTED TRAINING

INTRODUCTION

Training received today by soldiers entering the U.S. Army and those in many of the advanced Army courses is conducted using a strategy introduced a decade ago called performance-oriented training (How to Prepare and Conduct Training, DA Field Manual 21-6). Performance oriented training (POT) streamlines the instructional process material by eliminating abstract and theoretical material that is peripheral to the execution of the task being taught. A central premise of this method of instruction is that learning is most effective when the student is actively engaged in the process of learning. The emphasis is on practicing the steps of a task rather than on listening to an instructor talk about the task. Little time is devoted to explaining why a procedure must be performed in a particular way. Learning and retention of the procedure is expected to follow from repetition of the task during practice.

With its emphasis on practicing specific behaviors in response to specific cues, POT has as its genesis the learning theory tradition of behaviorism or associationism. According to this tradition, task performance is viewed as a series of pair-wise stimulus-response connections (Estes, 1976). These stimulus-response (S-R) connections are strengthened by repeated presentation of the stimulus with reinforcement or feedback given for correct responses. Thus, procedures are treated as chains of stimulus-response associations, with each response being the stimulus for the succeeding response until the procedure is complete (Cox & Boren, 1965; Gagne, 1965). In contrast, and arising in reaction to the behaviorist tradition is the information processing or cognitive approach (Diewart & Stelmach, 1978; Estes, 1976; Glaser, 1982). For the purposes of the present research, the primary difference is that in the cognitive approach, attempts are made to understand the cognitive, complex mental processes that operate during learning and performance (Estes, 1976). Whereas the behaviorist tradition emphasizes observable conditions and events (environmental stimuli and students' overt responses), the cognitive approach is also interested in the mental processes that are assumed to mediate S-R connections. The assumption is that by understanding these mental processes, training can be improved. Glaser (1982) has argued that although behaviorist approaches still tend to dominate applied learning strategies, cognitive psychology has become the dominant force in theoretical psychology. The focus of this research is on an application of theoretical cognitive psychology to an applied learning situation, specifically the instruction of armor procedural tasks with the expectation that acquisition and retention can be enhanced.

Before continuing it should be noted that S-R behavior theory, in general, is not viewed from the cognitive approach as necessarily incorrect, but rather as incomplete (Anderson, 1976; Estes, 1976). That is, advocates of the cognitive approach argue that while S-R connections are being learned, connections in memory are being organized in such a way as to facilitate retrieval of the connections. In a similar sense, POT may

not be wrong, but it may be possible to improve POT by adding information to the basic POT instructional strategy which will aid the mental processes associated with learning.

### Organization of Memory

Central to the study of cognitive organization of memory has been the concept of clustering (Battig & Bellezza, 1979, Dewart & Stelmach, 1978; G. Mandler, 1979, J. Mandler, 1979; Puff, 1979, Shuell, 1969, Tulving, 1962). Clustering is the tendency during or following learning to recall together items which are somehow related even though there is no requirement to do so. Glaser (1982) and Gilmartin, Newell, and Simon (1975) have suggested that novices and experts differ in their performance of various tasks due to how well they have organized task information in memory. Presumably the task proficiency of experts is related to the accessibility of task information. Accessibility is facilitated by remembering the task as clusters of related steps with those clusters in turn organized in some systematic pattern called a schema.

From the training perspective it is important to note that the process of organizing takes time (Pellegrino & Ingram, 1979; Schvaneveldt, Goldsmith, Durso, Maxwell, & Acosta, 1982), and may be inefficiently accomplished by low aptitude individuals (Glaser, 1982; Weinstein, Underwood, Wicker, & Cubberly, 1979). In order to improve training, instructional techniques may be designed to facilitate the development of cognitive task organization. As a result of improving cognitive organization, long-term performance may be improved, either from a direct effect of organization on retention (i.e., well organized material may be forgotten less quickly) or from improved initial acquisition (i.e., the task is learned better during the training period).

There are a variety of dimensions along which informational items being learned might be organized. Any judgment dimension (e.g., size, weight) on which items may be similar can be used to cluster items (J. Mandler, 1979; Shuell, 1969). Furthermore, "when an obvious form of organization is provided...the subject will usually use the organization provided. When no obvious form of organization is provided...the subject will find more subtle forms of organization to use" (Shuell, 1969, p. 367).

Two learning tasks are apparent in these statements: (1) selecting an organizing strategy or schema, and (2) applying the schema to the specific items or material to be learned. Whether an organizing schema is apparent in a set of material depends on the prior experience of the individual learning the material. That is, learners can use schemata which were previously mastered and whose characteristics match the material to be learned (Abelson, 1981; Ehrlich, 1979; Glaser, 1982; Thorndike, 1981). On the other hand, when no relevant schemata or organizing structures exist (as in the case of learning unrelated words or material in a completely novel area), one must be developed, and at the same time, the to-be-learned material must be coded into it. J. Mandler (1979) has termed the former process "top-down" and the latter "bottom-up." For training design, the implication is that learning may be facilitated to the extent that (1) general schemata based on prior experiences of individuals are utilized for

learning new material (Glaser, 1982), or (2) memory organization mnemonics are presented which help students to develop memory organizations for the material (Battig & Bellezza, 1979).

### Training with Memory Mnemonics

A number of studies have been conducted using military personnel and/or military type tasks to examine the potential of using memory organization strategies to increase training effectiveness (Griffith, 1980; Griffith & Atkinson, 1978; Weinstein, Rood, Roper, Underwood & Wicker, 1980; Singer, Ridsdale & Kovieneck, 1979). The approach of these studies has been first to teach students a mnemonic (e.g., mental imagery) and then to present the task with students instructed to use the mnemonic to learn the task. Montague (1982) has suggested that while this approach has been successful with relatively simple tasks, its application to more complicated tasks is less certain. In general, the studies using military type tasks have failed to show consistently increased acquisition or recall of the tasks being taught.

It seems clear that memory organizations play an important role in learning and recall, but that designing training to facilitate memory organization has been more problematic. This conclusion is not surprising in light of Thorndike's (1981) statement that much more attention has been given to describing memory structures (e.g., Friendly, 1979; G. Mandler; J. Mandler; Reitman and Reuter, 1980) than to the processes related to the development of these structures. Without adequate theoretical background describing how memory becomes structured, the selection of appropriate organizing strategies to teach students to use in learning new tasks cannot be the product of scientific deduction. An additional problem is that the memory strategies previously studied have been generic mnemonics which, when used for several tasks or sets of materials, tends to produce interference between the tasks or material (Griffith & Atkinson, 1978; Thorndike, 1981). Furthermore, because these mnemonics are not a part of the material being learned, soldiers who are not accustomed to developing elaborate memory structures (Weinstein, et al., 1979) may view these strategies as cumbersome and irrelevant.

An approach suggested by Morrison (1982) may circumvent these problems. His suggestion was not to teach an organizing strategy to students for them to use in developing their own structure, but rather to first develop organizing structures specifically for each task to be trained and then to teach those structures to all students. The purpose of this study was to examine this training strategy, by first developing memory organizing structures for each of several procedural tasks and then constructing training programs to present those structures.

### Memory Structure Analysis

For the suggested training approach to be implemented, memory structures must be constructed for each task to be trained. Rationally and empirically guided approaches have been proposed for analyzing how procedural tasks are organized in memory (Morrison, 1982; Morrison & Goldberg,

1982). Both approaches result in the steps of a procedure being clustered categorically (i.e., by common objective), with these clusters of steps themselves clustered to form a hierarchical (tree) structure. Two tasks used in this study (Clear the M240 Machinegun and Operate the AN/VRC-64 Radio) were analyzed by Morrison (1982) using an adaptation of Friendly's (1979) empirically guided approach. Briefly, time intervals between task steps recalled by soldiers familiar with the tasks were averaged (using medians) across soldiers. These median response intervals were then analyzed with Johnson's (1967) maximum distance cluster analysis, and the results interpreted as a hierarchical memory structure. By analyzing recall patterns across individuals, Morrison (1982) implicitly assumed that there existed a memory structure for each task which was shared by all respondents. This is not an unreasonable assumption from the viewpoint of Gestalt psychology, which assumes "that an optimal or natural organization exists for all situations or any given situation" (Diewart & Stelmach, 1978, p. 244). Certainly if there is any tendency for persons to organize a task the same way, it is this common structure that should guide instruction of the task.

Two additional tasks were included in the study as tasks representative of procedures which incorporate branching at check points. These tasks (adjust the M2 machinegun headspace and respond to an M1 tank engine compartment fire) were analyzed rationally. These analyses are presented in Hoffman (1983). Guidelines used to conduct the analyses are presented as follows:

1. Determine the overall objective and subobjectives of the task.
2. Divide task steps into clusters of related steps.
3. Clusters should have no more than five steps each.
4. Clusters should represent a recognizable activity or subobjective of the task.
5. Any branching points in the task should be used to define clusters.
6. Clusters should be named, using an action verb, to describe its activity.
7. Join related clusters to form higher order clusters.
8. Clusters should form a hierarchy (tree structure) of goals and subgoals describing the entire task.

A tree structure-type diagram was designed for each of the four tasks to show its organization. Diagrams included brief phrases for each step together with the name of each cluster. Line drawings depicting the equipment components involved in the steps of each cluster accompanied the names of the clusters.

#### Development of Training Strategies

The major thrust of this research was to examine the hypothesis that providing students with task organization information can facilitate learning and recall of that task. As an applied research project, it was desirable to be able to draw some conclusions directly applicable to Army

training from the results of the effort. Given the argument stated previously that the Army's standard training approach, POT, is not built on incorrect learning principles, but rather on an incomplete set of principles, POT was taken as the starting point for this research. Thus, POT served as the standard method of instruction against which alternative training strategies could be evaluated, and it provided the basic instructional format to which memory organizing information was added.

Two experimental training programs were built on the basic POT design. The difference between POT and the two experimental programs was the addition of task organization information to the experimental programs. The expectation was that students would be able to perform the task more accurately after having received the memory organization information. The difference between the two experimental approaches was in the timing of the presentation of the memory organization information. One strategy presented information concerning the memory organization of the task prior to POT-style presentation and practice of the steps. Since a structure was provided prior to the detailed material, this approach was called the "top-down" approach, analogous to the terminology of J. Mandler (1979). The top-down, or structure first, method was a straightforward application of the proposition that a previously learned task structure can guide the acquisition and subsequent recall of new, detailed material. Thus, students were presented the set of interrelated clusters to organize the task in memory prior to being presented the elemental steps of the task.

The second alternative to POT, also based on the use of memory organization, first allowed students to have POT style hands-on experience with the elemental steps of the procedure being taught and then presented them with the task structure to organize the storage of those steps in memory. This strategy was called "bottom-up." The rationale was that, for recruits who may not be used to employing strategies other than rote learning (Weinstein, et al., 1979), the clustering and labeling of steps may be too novel and too abstract. By presenting the steps first, these students would have a better idea of what the labels mean and therefore how to use them in organizing their memory of the task. This approach also corresponds to the instructional sequencing advocated by Gagne (1965) in which elemental, concrete connections are presented before more general, abstract information. Structure information was presented by beginning with the steps and showing how they could be clustered, and then showing the relationships among the clusters. After the structure had been presented, students continued practicing the task.

Although the effort of learning task organizations may have appeared to be an extra burden during training, it was an effort that appeared likely to pay dividends in task recall (Segal, 1969; Shuell, 1969). Diagrams, prepared from the task structure diagrams, and verbal presentations were used to convey the task structures during the training program. Emphasis was placed on the cluster names under the hypothesis that these names would act as a mnemonic bridge between a task and its elemental steps. Students were told that this information would help them remember how to do the tasks.

To evaluate the effectiveness of these two experimental training strategies, training programs were developed using both strategies for four

different procedural tasks performed by armor crewmen. In addition, training programs were prepared for each task using basic POT guidelines (FM 21-6). Thus, the addition of task structure information could be compared to a rote condition of no structure information (top-down and bottom-up versus POT) and the effects of timing of presentation of structure information could be examined (top-down versus bottom-up).

Three options were considered regarding the amount of training soldiers were to receive in the experimental comparison of the three training programs. Common in the typical Army application of POT, students are trained in groups and rotate practicing on the equipment until each has mastered the task or until the time available for instruction runs out. To remove any extraneous group effects, soldiers in the experimental comparison were trained individually. Thus, experimental training could be designed with training to mastery or to a fixed time period. A third design option was to give each student a fixed number of practice trials, thereby controlling practice. The decision was made to train for a fixed time period based on the applied emphasis of the research and the tremendous time constraints under which Army trainers must schedule courses. Thus, any improved training strategy must not use more training time than it is worth. Because the top-down and bottom-up training strategies include additional information, presentation time takes longer than for POT. If training to mastery or for a fixed number of trials were used, total training time would very likely be longer for the top-down and bottom-up strategies. If students who received the structure were subsequently to recall the task better in delayed testing, one could argue that because practice is a powerful learning variable, had students been able to practice during the extra time it took experimental students to receive the memory structure information, then delayed performance differences would be mitigated or even reversed. The structure strategies would be viewed as having no benefit relative to the extra training time required. For either top-down or bottom-up training strategies to be acceptable to the Army training system, they must not take longer than POT and yet still produce greater task mastery and retention.

The result of this decision to train for a fixed time period was that training strategy and amount of practice were completely confounded. As a general rule, practice can be expected to increase acquisition and recall. Therefore, if the structure strategy, with less practice, were to lead to improved recall, it would seem safe to conclude that the improvement was due to the added structure information. On the other hand, if the structure strategy were to lead to reduced recall, the effect could be more parsimoniously attributed to reduced practice. Clearly if less emphasis were given to the value of training time, training to a fixed number of trials might provide more theoretical information about the affects of providing structure information. If more subject resources were available for the research, practice time could have been systematically varied, number of trials recorded and a regression analysis conducted providing even greater explanatory capacity (e.g., the additive and interactive effects on time and trials). On the other hand, if task structure information is a powerful benefit, then its effects should show up under fixed time conditions. Thus, the fixed time design may be the most stringent design, but if successful, it is the most persuasive test of the structure training strategy.

To assess the relative effects of the training programs on recall, soldiers were tested approximately 48 hours after their training. Because of the differences in presentation (primarily verbal) and practice ratios for the training strategies, testing consisted of both hands-on performance of each task and verbal recall of the steps in the task. In addition, memory structure analyses were conducted using the verbal recall protocols for students in each training strategy to assess training effects on students' memory organization.

## METHOD

### Participants

Enlisted soldiers naive to the tasks participated in training and testing. Soldiers were divided into three training groups with soldiers in each group ( $N=19$ ) receiving only one of the training strategies.

### Training Programs

Training programs were developed for each task using each training strategy. Outlines for these programs are presented in Tables 1 and 2. Slide/tape presentations presented the task structure and all verbal commentary except for the practice dialogue. Slides were prepared from structure diagrams, which showed the entire structure, with and without the steps included, and which showed each cluster separately. Complete structure diagrams are shown in Figures 1 through 4. Presentation of the slides was synchronized with the verbal commentary. For the M2 and engine fire tasks, slides also focused on the branching between clusters. (No slides were presented in POT programs.) Instructors demonstrated the task (following the verbal instructions being presented by the taped commentary), and talked the student through the task using a standardized protocol. Instructors also provided feedback and assistance while students practiced the task.

Students in the top-down and bottom-up training programs were also instructed to say out loud the cluster names as they practiced the task. Because of the fixed time limits across training conditions, no time was available for students to verbally rehearse the structure except while practicing.

Complete descriptions of each training program are in Hoffman (1983).

### Equipment

Training was conducted using the actual equipment for the M240 machinegun, M2 machinegun, and AN/VRC-64 radio tasks. Training for the engine compartment fire task was conducted with an M1 driver station

Table 1

Outline of Top-down Training Program

| <u>Media</u>   | <u>Event</u>   |
|--|--|
| 1. Tape  | Name task.   |
| 2. Tape  | Present orientation statement (brief description of what the task is about, e.g., who does it, why, what is being done, etc.).   |
| 3. Tape  | Present outline of training procedure.<br>-tell students that they will be told how to remember the steps,<br>-show them a demonstration of these steps,<br>-give them practice using the equipment. |
| 4. Tape/instructor pointing to parts   | Introduce nomenclature (only relevant parts)   |
| 5. Slide, tape   | Present top level of structure   |
| 6. Tape  | Tell students to remember by using cluster labels.   |
| 7. Slide, tape   | Present subclusters for first cluster.   |
| 8. Slide, tape, instructor   | Present and demonstrate steps of each subcluster.  |
| 9. Tape  | Give statement signaling the end of subcluster (may be omitted if steps are simple and very limited in number.)  |
| ...Repeat 8 & 9 for each subcluster within first cluster.  |  |
| 10. Tape   | Give statement signaling end of cluster by reviewing names of subclusters.   |
| 11. Tape   | Review top of structure.   |
| ...Repeat 7 to 11 for each cluster. For clusters without subclusters, omit & 9; for 8 present all steps and for 10 review steps. |  |
| 12. Tape   | Review total structure.  |
| 13. Instructor   | Talk student through task one time, highlight cluster names.   |
| 14. Instructor   | Tell student to practice using cluster names.  |
| 15. Instructor   | Aid and reinforce student's practice.  |

Table 2

Outline of Bottom-up and POT Training Programs

| <u>Media</u>                                   | <u>Event</u>  |
|--|---|
| 1. Tape  | Name task.  |
| 2. Tape  | Present orientation statement (brief description of what the task is about, e.g., who does it, why, what is being done, etc.).  |
| 3. Tape  | Present outline of training procedure<br>-show them a demonstration,<br>-give them practice,<br>-give additional information to help them remember,*<br>-give additional practice.* |
| 4. Tape,<br>instructor<br>pointing<br>to parts | Introduce nomenclature (only relevant parts).   |
| 5. Slide,<br>tape,<br>instructor               | Give demonstration (step by step, steps numbered).  |
| 6. Tape  | Review steps (verbal only).   |
| 7. Instructor                                  | Talk student through task one time.   |
| 8. Instructor                                  | Let student practice the task two times.  |
| 9. Tape  | *Introduce structure presentation.  |
| 10. Tape,<br>slides                            | *Show how steps are combined into subcluster...repeat 10 for each subcluster in first cluster.  |
| 11. Tape,<br>slides                            | *Show how subclusters are combined into a cluster (or omit 10 and form steps into cluster has no subclusters.)  |
| ...Repeat 10 and 11 for each cluster.          |   |
| 12. Tape,<br>slides                            | *Show how clusters form total organization of the task.   |
| 13. Tape                                       | *Give instruction for additional practice (say out loud cluster names).   |
| 14. Instructor                                 | Aid and reinforce student's practice.   |

<sup>a</sup>POT training training strategy was constructed by omitting the events marked with an "\*", bottom-up training included all events.

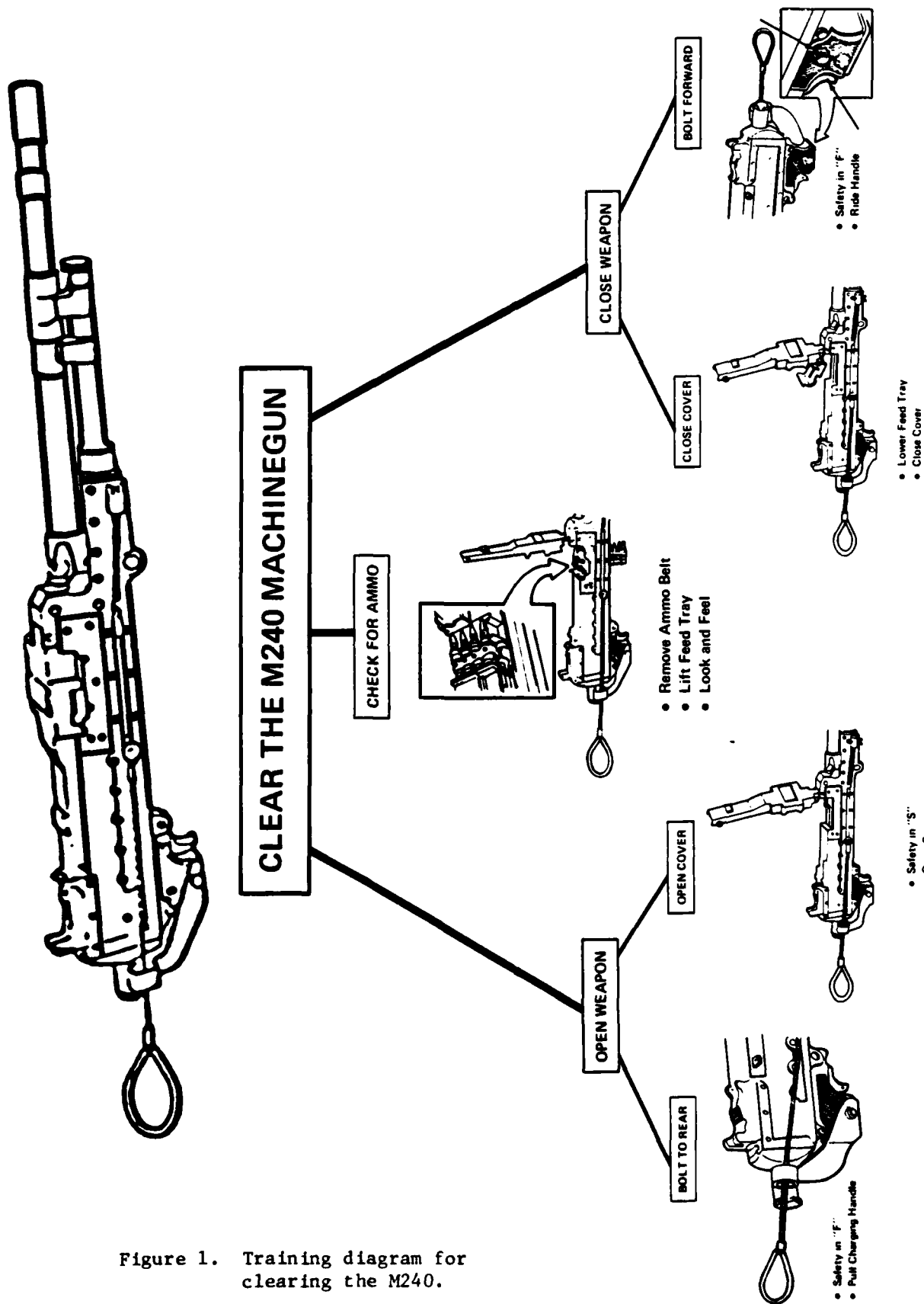
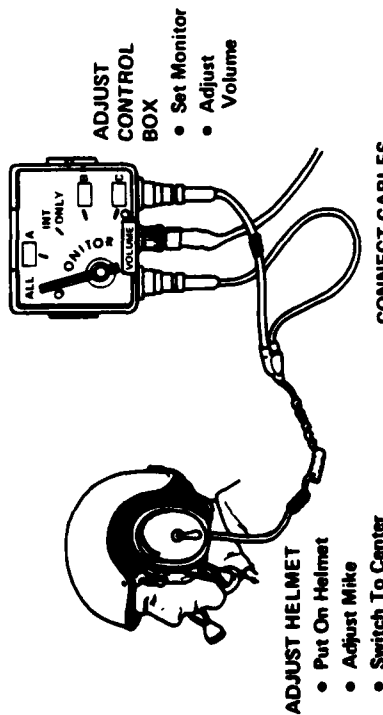


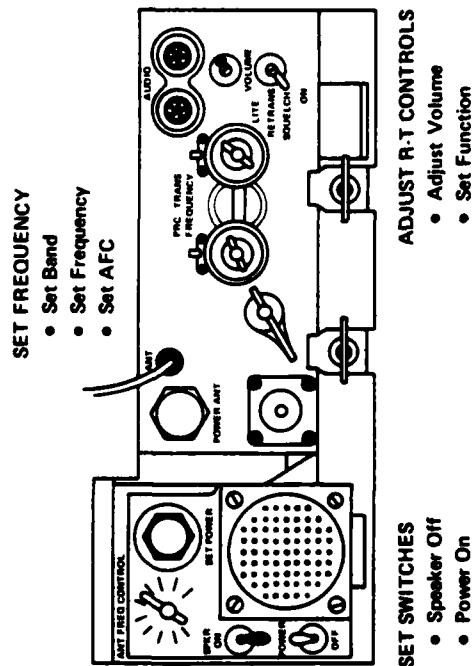
Figure 1. Training diagram for clearing the M240.

# OPERATE THE AN/VRC - 64 RADIO

## PREPARE CREWMAN'S STATION



## SET RADIO TRANSMITTER



## SET AUDIO FREQUENCY AMPLIFIER

- Set Radio Transmitter
- Set INT Accent
- Set Main Power
- Set Power Circuit Breaker

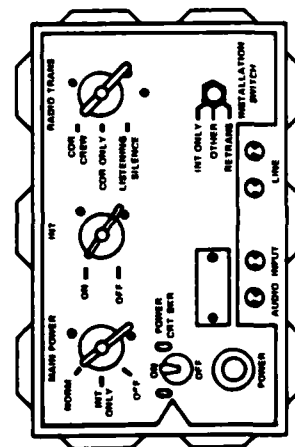


Figure 2. Training diagram for operating the AN/VRC-64 radio.

# ADJUST HEADSPACE M2 MACHINEGUN

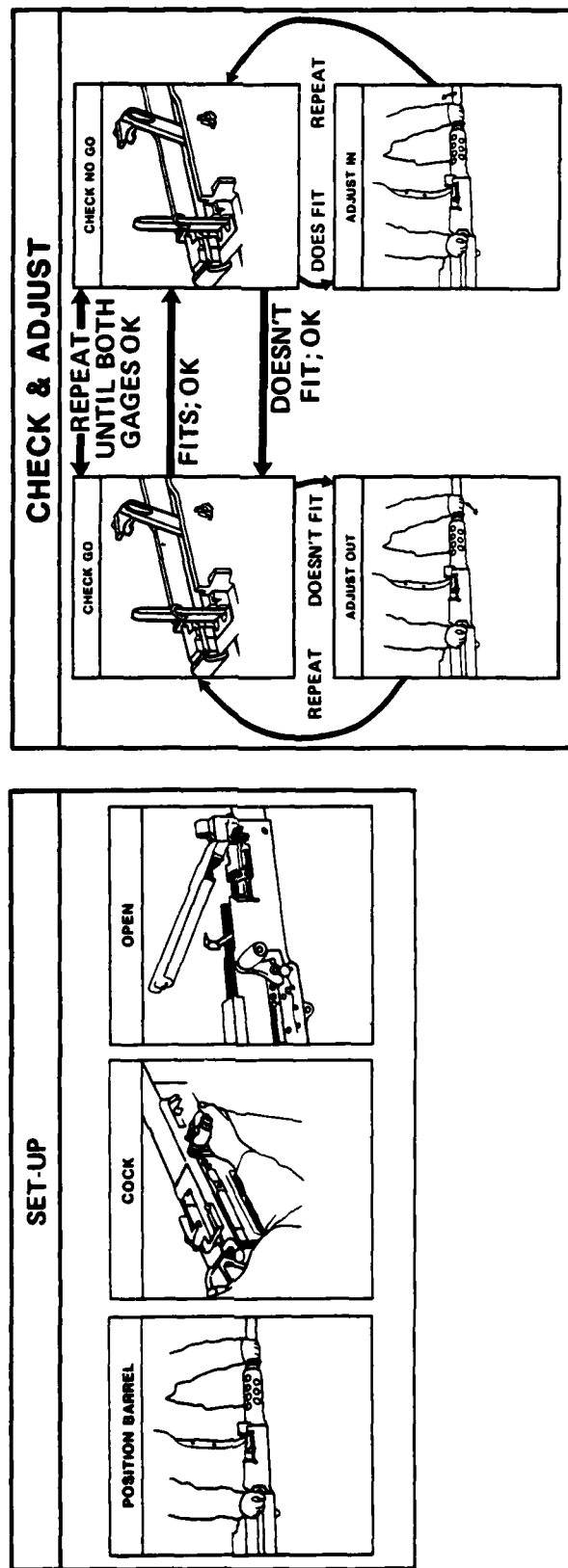


Figure 3. Training diagram for adjusting the M2 headspace.

# ENGINE COMPARTMENT FIRE M1 TANK

## DETECT & DISCHARGE

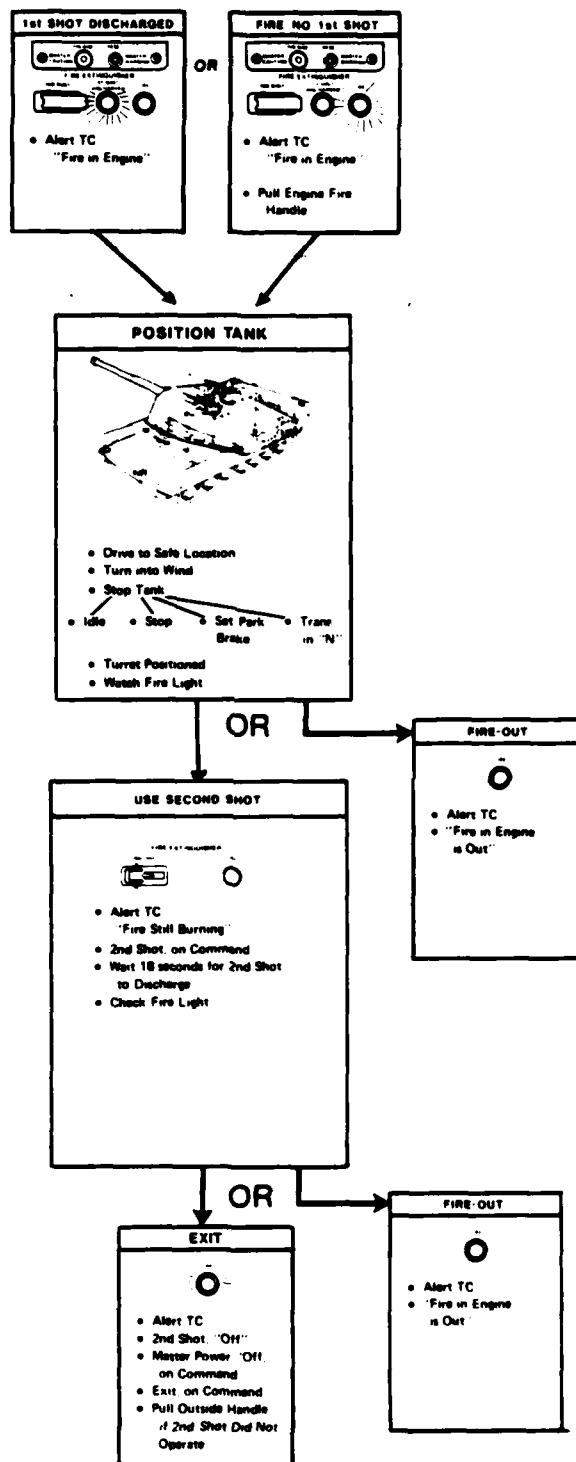


Figure 4. Training diagram for responding to an engine compartment fire.

mockup. This mock-up contained all the panels, switches and controls, in their relative spatial position needed to perform the steps of the task. An automated slide projector/tape recorder device was used to present task structure slides and taped verbal presentations.

### Procedure

All soldiers received individual training and testing on the four M1 tasks. For each soldier, training on all four tasks occurred sequentially during a 2½-3 hour block of instruction. Four soldiers were trained at a time, one on each task, with soldiers being rotated between tasks to achieve some degree of counterbalancing of order of task presentation. That is, for each set of four students, order of training was scheduled such that each task preceded and followed every other task once, and each task was presented once in each presentation position order. Whereas, all soldiers were trained on all four tasks, any one soldier was trained by only one method. That is, soldiers were nested within method and crossed with tasks.

During soldier's practice, the beginning time (measured from the start of the session) and errors made for each trial were recorded by the instructor. For the M2, radio and fire tasks, training sessions were 30 minutes each. For the M240 task, training was scheduled for ten minutes. However, for some bottom-up students to receive one practice trial after their structure presentation, their training time was extended approximately by one minute.

Soldiers were tested two days after training. Each soldier was asked to perform the task twice. They were then asked to describe the task as if they were telling someone how to do the task. Their descriptions were tape recorded. Although order of performance and verbal was constant, it was decided that (a) balancing order was too costly in terms of subject resources and (b) performance was the more important variable and should not be contaminated by having soldiers verbally recall the task before performing it. Order of testing the four tasks was counterbalanced in a manner similar to the training schedule with the additional stipulation that for any student, testing order was not the same as training order.

### Dependent Variables

Dependent variables for the delayed testing sessions included total number of errors made for both trials, and total number of errors made during verbal recall. Errors included omissions of steps and misordering of steps. The M2 machinegun task required repetition of steps for correct performance of the task, however, the number of repetitions could vary. Furthermore, several types of errors could perpetuate themselves by leading to more repetitions. Therefore, rather than counting total errors for the M2 task, errors were counted only for the first repetition of steps. Also, for the M2 task, some of the steps required fine motor control to achieve the right "feel" in making a check or adjustment. Because the focus of this study was on memory of steps, if a student attempted these steps correctly, no error was assessed.

Variables of interest for the training sessions included number of practice trials plus several variables descriptive of task acquisition. Because training sessions were conducted with a fixed time, number of practice trials varied across students. Therefore an exact comparison of trial-by-trial performance was not feasible. For example, sample size dwindles in each condition as the number of the trial increased and any adjustment that might be made (e.g., including only students with a certain number of trials) would misrepresent the training process. In lieu of trial-by-trial comparisons, errors on the first and last (whatever number) trials, and number of correct trials were analyzed. Mean trial-by-trial performance was calculated with the understanding that sample size was not constant.

For performance during training, all errors were noted for the M2 as well as the other four tasks. In contrast to the test, students in practice received feedback each time they missed a step. Thus, each time the same step was missed on subsequent repetitions of that step in a given trial on the M2 tasks, an error was counted. Because of equipment characteristics the number of steps and, therefore, potential number of errors was not constant between trials on the M2, percent of steps correct was used rather than total errors.

## RESULTS

Training effects on acquisition and recall variables were first assessed by one-between, one-within repeated measures ANOVA with experimental soldier crossed with tasks and nested within training strategies. Significant effects were followed up with one-way ANOVA's and Newman-Keuls post hoc comparisons for each task. Because the focus of this research is on recall, these results are presented first.

### Recall

Dependent variables for assessing training strategy effects on recall were total errors for both performance trials. Verbal recall errors were scored from the tape recorded descriptions provided by each student. The description given by one student for the radio task was inaudible. His score was estimated by the procedure discussed by Myers (1979, p. 177-178), and one degree of freedom subtracted for the error term degrees of freedom. Figures 5 and 6 present group means for these variables. Table 3 presents results for the repeated measures ANOVA for each variable. Task effects were significant for both variables which simply means that the tasks differed in difficulty. Training and training by task interaction effects were also significant. Thus, training strategy did appear to affect delayed recall, but the effects were task dependent.

One-way ANOVA were conducted for each task for each dependent variable. These results appear in Table 4. Significant effects on performance and on recall errors were found for the M2 and fire tasks. Newman-Keuls analyses were then conducted for the delayed test dependent variables for the tasks which showed significant one-way ANOVA. Newman-Keuls results are

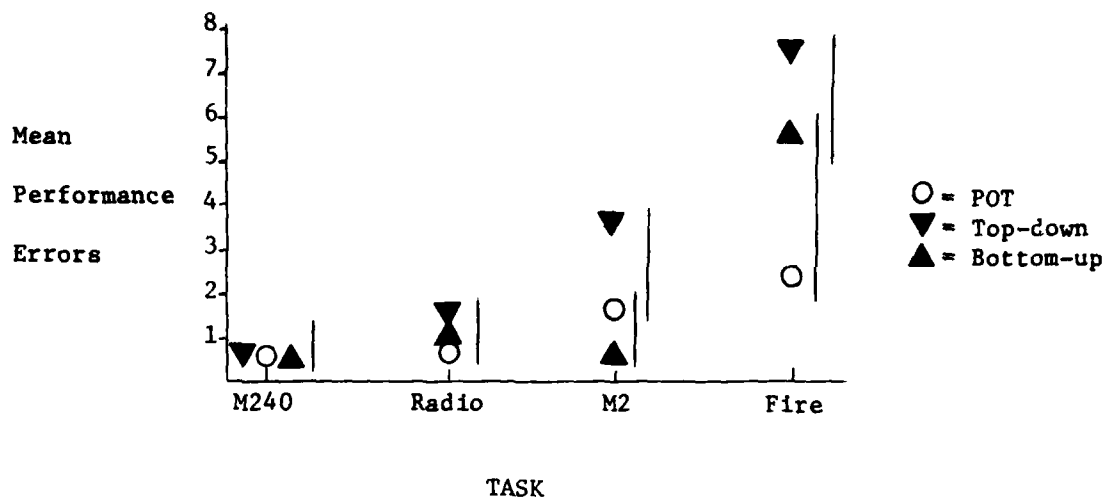


Figure 5. Errors during delayed performance. (For this and all subsequent figures, vertical lines connect training strategy means, within tasks, not significantly different using Newman-Keuls.)

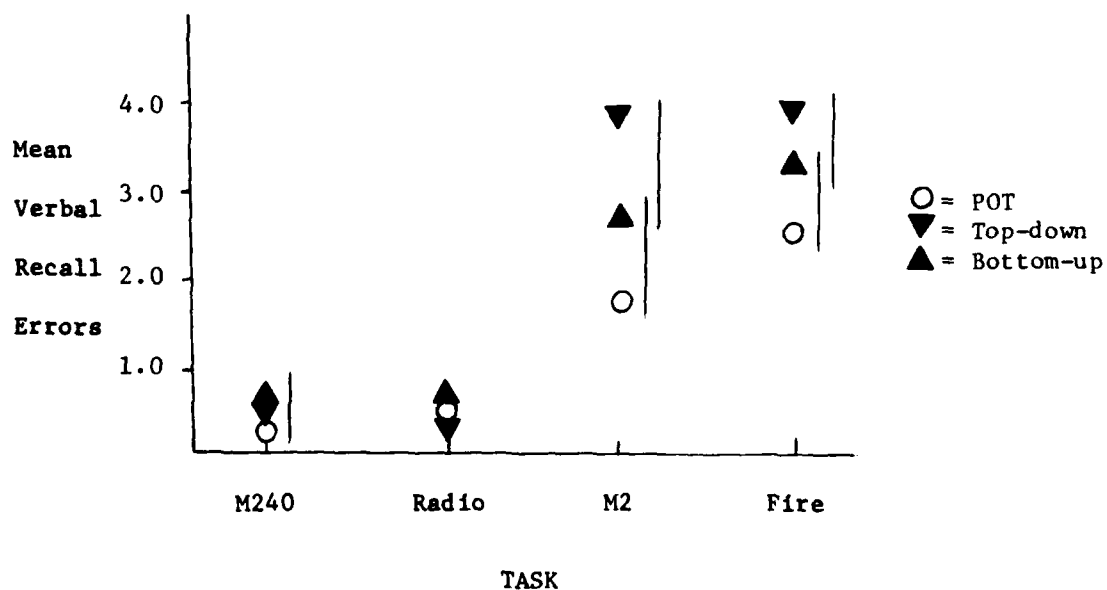


Figure 6. Errors during verbal recall.

Table 3  
Repeated Measures ANOVA for Delayed Test

| Dependent Variable       | Between     |        |             | Within          |             |        |
|--------------------------|-------------|--------|-------------|-----------------|-------------|--------|
|                          | Training    | Error  | Task        | Training X Task | Error       | Within |
|                          | Mean Square | F      | Mean Square | F               | Mean Square | F      |
| Total Performance Errors | 52.99       | 4.53*  | 11.70       | 221.20          | 31.37**     | 41.24  |
| Verbal Recall Errors     | 20.76       | 6.50** | 3.19        | 135.04          | 78.51**     | 47.07  |
| df <sup>a</sup>          | 2           | 54     | 3           | 6               | 6           | 162    |

\*  $p < .05$

\*\*  $p < .01$

<sup>a</sup> Error term degrees of freedom reduced by one for verbal recall errors due to missing data estimation.

Table 4  
One-Way ANOVA for Training Strategy  
Effects on Delayed Test for each Task

| Dependent Variable       | TASK       |            |            |            |       |        |
|--------------------------|------------|------------|------------|------------|-------|--------|
|                          | M240       | Radio      | M2         | Fire       |       |        |
|                          | MS Between | MS Between | MS Between | MS Between | F     | F      |
| Total Performance Errors | 0.02       | 0.01       | 0.56       | 34.32      | 10.29 | 7.41** |
| Verbal Recall Errors     | .84        | 1.85       | 0.75       | 28.00      | 4.02* | 3.44*  |

\*  $p < .05$

\*\*  $p < .01$

presented in the figures by connecting training groups, within tasks, for which no treatment effects were detected. Thus, group means which were significantly different ( $p < .05$ ) are not connected in the figures. All three groups are connected for the M240 and radio tasks which showed non-significant one-way ANOVA.

Top-down training was significantly different ( $p < .05$ ) from POT training for the engine compartment fire task for both delayed test variables. These differences were opposite the expectation; POT students showed the best performance on the fire task, and top-down students the poorest performance.

For the M2 task, top-down training was significantly different ( $p < .05$ ) from POT in verbal recall errors and significantly different ( $p < .05$ ) from bottom-up performance errors. Again, top-down students exhibited the poorest performance.

The pair-wise verbal recall and performance errors results for the M2 and fire extinguisher tasks are inconsistent, suggesting either a Type I or Type II statistical error. For example, if in the population, POT and top-down mean performance errors are different, then the bottom-up population mean must be different from either the POT population or the top-down population mean, or both. It cannot be equal to both. Thus, either POT and top-down are not different (Type I error), or bottom-up is different from POT or top-down or both (Type II error). Thus, when the two extreme groups are significantly different but the middle group is not significantly different from either of the others, an error is present and interpretation of the pattern of results is somewhat ambiguous.

No training condition differences were observed for the M240 and radio tasks during delayed testing.

### Training

Training variables used to assess differential patterns of task acquisition for the three training strategies included number of practice trials attempted, errors on the first and last trials, and number of trials correct. Figures 7 through 10 present training strategy means for each task for these variables.

Table 5 presents results of repeated measures ANOVA for each of these variables. In all cases, the task effect was significant, again, indicating that the tasks differed in difficulty. For all variables, except number of errors on the first practice trial, the training strategy effect and the training by task interaction were significant. Thus, while it cannot be concluded that the presentation strategy affected initial practice (i.e., the addition of top-down information did not give those students a "head start"), it can be concluded the training strategy condition did influence acquisition, but that the nature of that influence was task dependent.

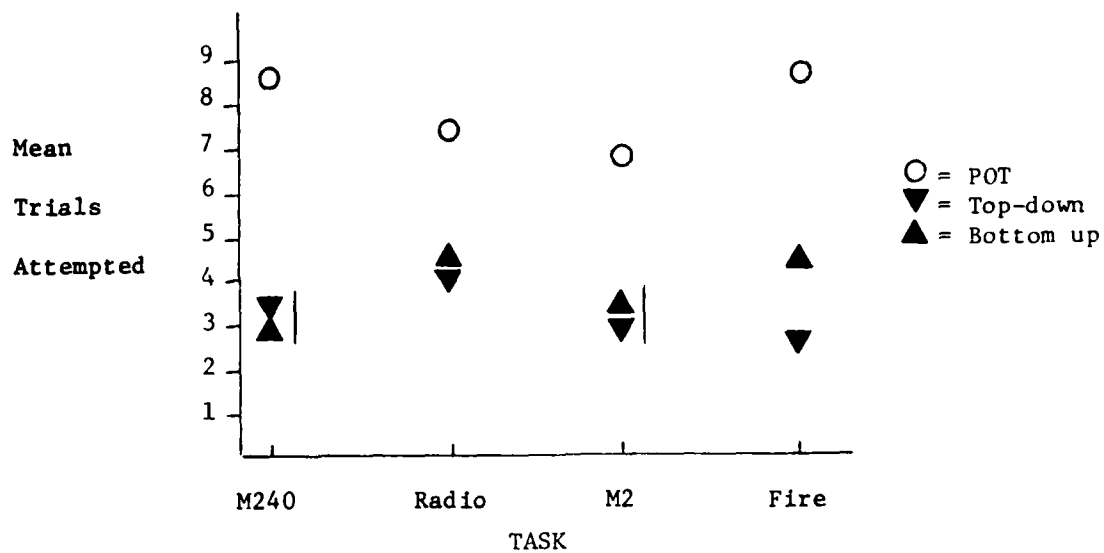


Figure 7. Practice trials attempted

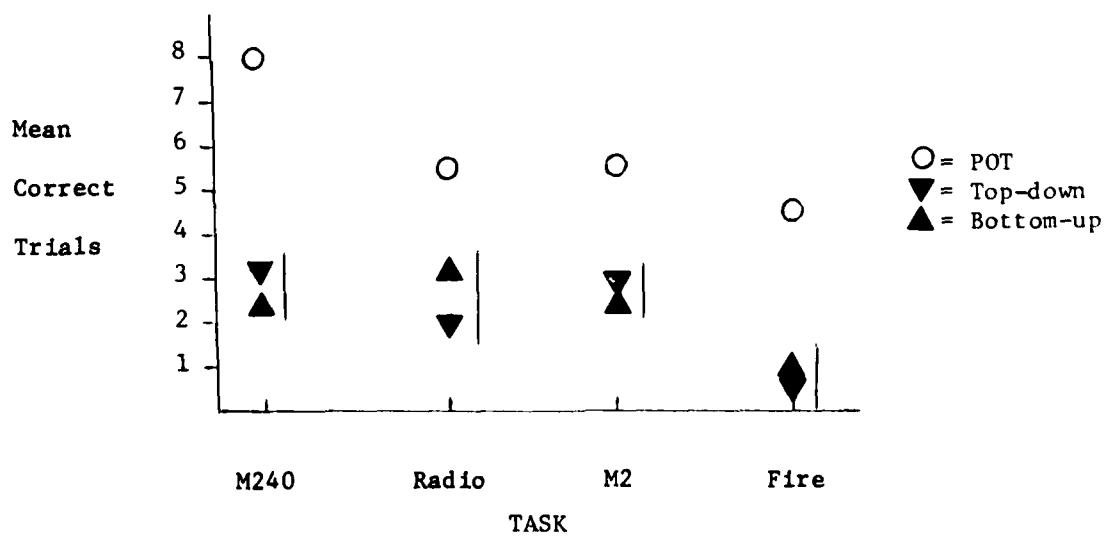


Figure 8. Number of correct trials in practice.

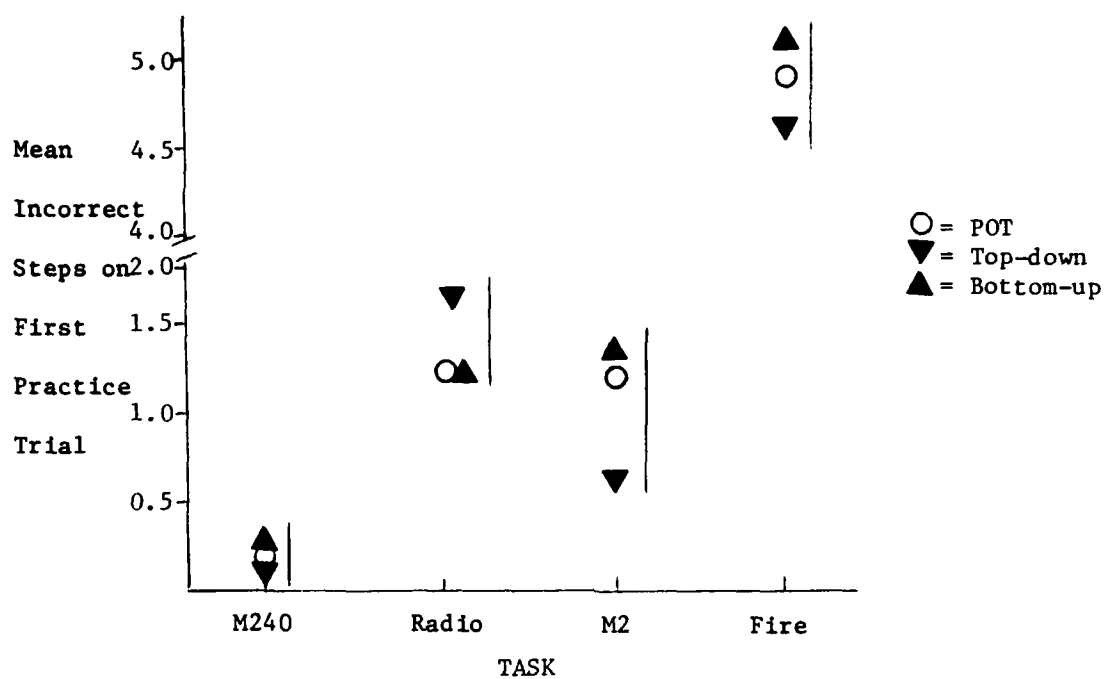


Figure 9. Incorrect steps on first practice trial.

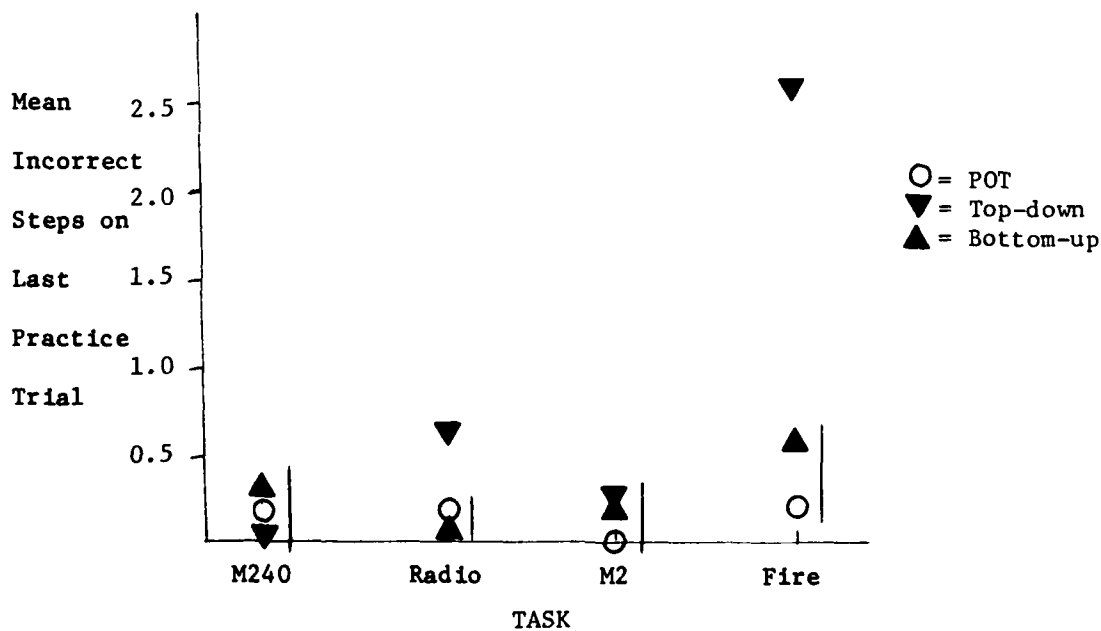


Figure 10. Incorrect steps on last practice trial.

Table 5

Repeated Measures ANOVA  
for Training Variables

| Variable              | Between                 |            |         | Within              |          |                 |
|-----------------------|-------------------------|------------|---------|---------------------|----------|-----------------|
|                       | Training<br>Mean Square | Error<br>F | Between | Task<br>Mean Square | F        | Error<br>Within |
| Trials attempted      | 521.80                  | 134.18**   | 3.89    | 9.78                | 7.56**   | 10.47           |
| Trials correct        | 362.86                  | 59.26**    | 6.12    | 68.45               | 34.31**  | 7.99            |
| Errors on first trial | 1.19                    | .49        | 2.42    | 234.41              | 143.10** | 1.32            |
| Errors on last trial  | 11.29                   | 9.64**     | 1.17    | 12.10               | 16.45**  | 6.91            |
| df                    | 2                       | 54         | 3       | 6                   |          | 164             |

\*  $p < .05$ \*\*  $p < .01$ 

Table 6

One-Way ANOVA for Training Strategy  
Effects on Training Variables for each Task

| Training Variable    | TASK          |         |               |         |               |         |
|----------------------|---------------|---------|---------------|---------|---------------|---------|
|                      | M240          | Radio   |               | M2      |               | Fire    |
|                      | MS<br>Between | F       | MS<br>Between | F       | MS<br>Between | F       |
| Trials attempted     | 179.17        | 42.55** | 74.89         | 65.79** | 91.79         | 53.48** |
| Trials correct       | 158.26        | 30.59** | 65.89         | 21.50** | 75.39         | 25.64** |
| Errors on last trial | .21           | 2.30    | 1.47          | 4.39*   | 0.37          | 1.55    |
|                      |               |         |               |         | 29.96         | 11.03** |

\*  $p < .05$ \*\*  $p < .01$

Table 6 presents the one-way ANOVA for each task for the five training variables with significant training and training by task interaction effects. Significant one-way ANOVA were followed up with Newman-Keuls comparison of training strategy means within the tasks. These results are again presented in the figures for these variables by connecting all three training strategy means for tasks with non-significant one-way ANOVA and leaving unconnected training strategy means found significantly different ( $p < .05$ ) using Newman-Keuls.

For trials attempted and trials correct, all four tasks showed significant training strategy effects. Figures 7 and 8 show that, as expected from the length of training presentation, POT students performed more practice trials, and in addition, they performed a greater number of trials correctly. Significant training effects on the number of errors on the last practice trial were found only for the radio and fire tasks.

The origin of these results are apparent in the comparison of trial by trial performance depicted in Figures 11 through 14. For all three tasks, the curves for the three training conditions overlap to a remarkable degree. No boost in performance is apparent at the beginning of practice for the top-down students nor any boost during practice for bottom-up students. Also, for the M240 and M2 tasks, all three training strategy curves are relatively high and flat. Thus, POT students had more correct trials simply because they attempted more trials. In contrast, for the fire task, performance improved over the first few trials. For this task then, it appears that POT students performed proportionately more trials after reaching a plateau in performance. Top-down and bottom-up students did not practice after reaching a plateau (and indeed may not have reached their plateau). This pattern also appears to fit the radio task except that the bottom-up students, who on the average, attempted more trials than the top-down students (see Figure 7) and therefore were more like POT students having practiced more trials after reaching a plateau.

The performance data for the delayed test are also included on the training trials performance figures (expressed as a percentage of steps correct) to facilitate comparison of training and testing. In general, these figures suggest that the greater the number of trials practiced beyond the point where performance reached a plateau, the better the test performance. These results confirm the expectation that if the structure strategy condition led to reduced recall, the effect would be due to the reduction in practice for those conditions.

### Structure Analyses

In addition to performance and recall, students' memory structures were analyzed using Morrison's (1982) adaptation of Friendly's (1979) structure analyses. That is, for each student and each task, inter-response time intervals between procedure steps were determined as the time (to the nearest second) between the initial words used to describe each step. For each training condition, the median time between the initial word of each pair of steps was calculated for each task. These median time intervals were then used to cluster task steps using Johnson's (1967) maximum distance cluster analysis. The results are depicted as twelve

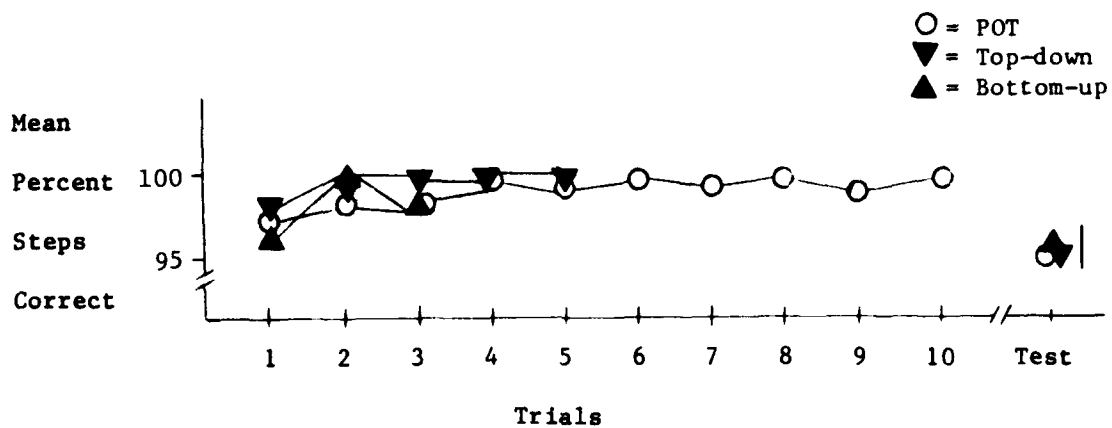


Figure 11. Trial by trial performance for clearing the M240.

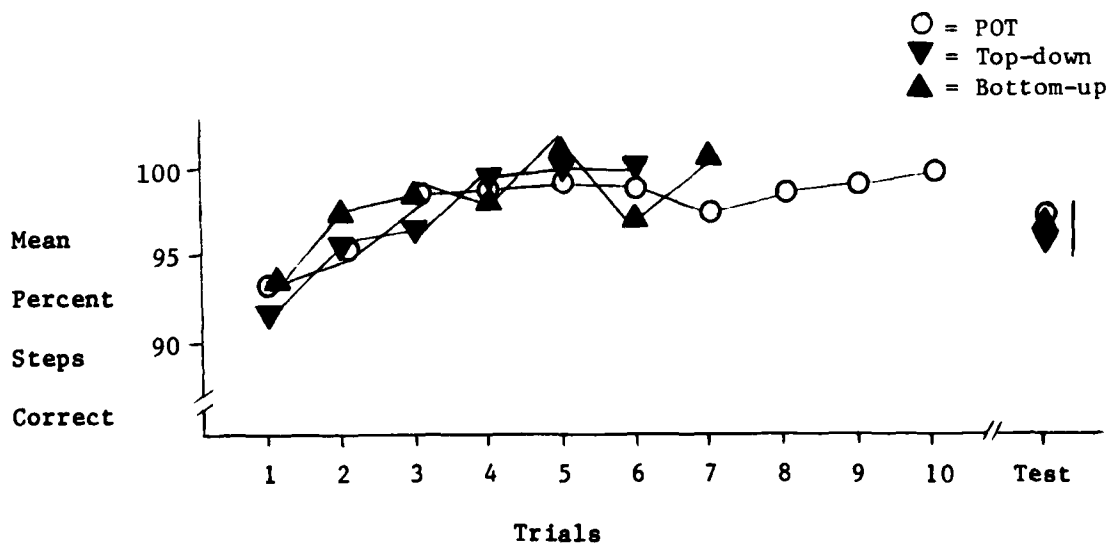


Figure 12. Trial by trial performance for operating the radio.

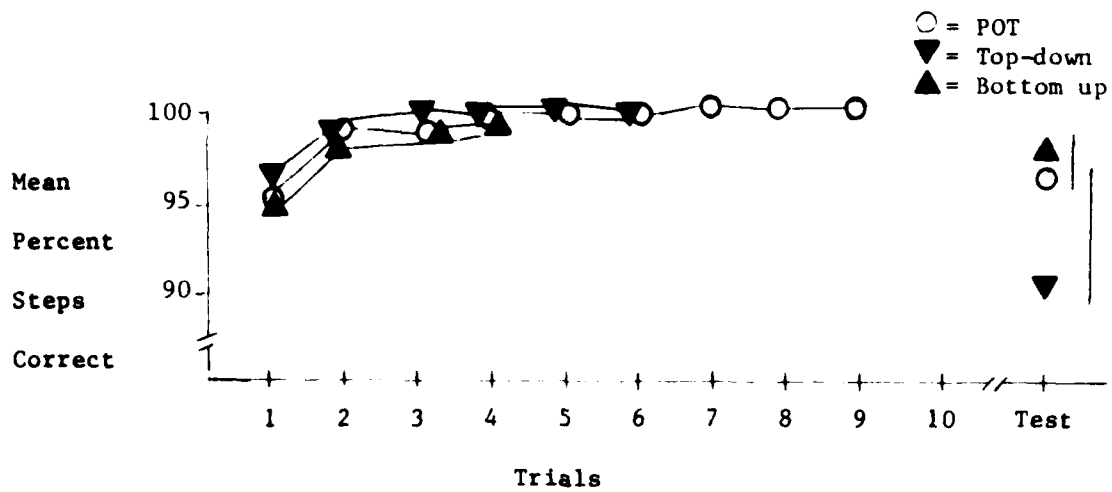


Figure 13. Trial by trial performance for adjusting the M2 headspace.

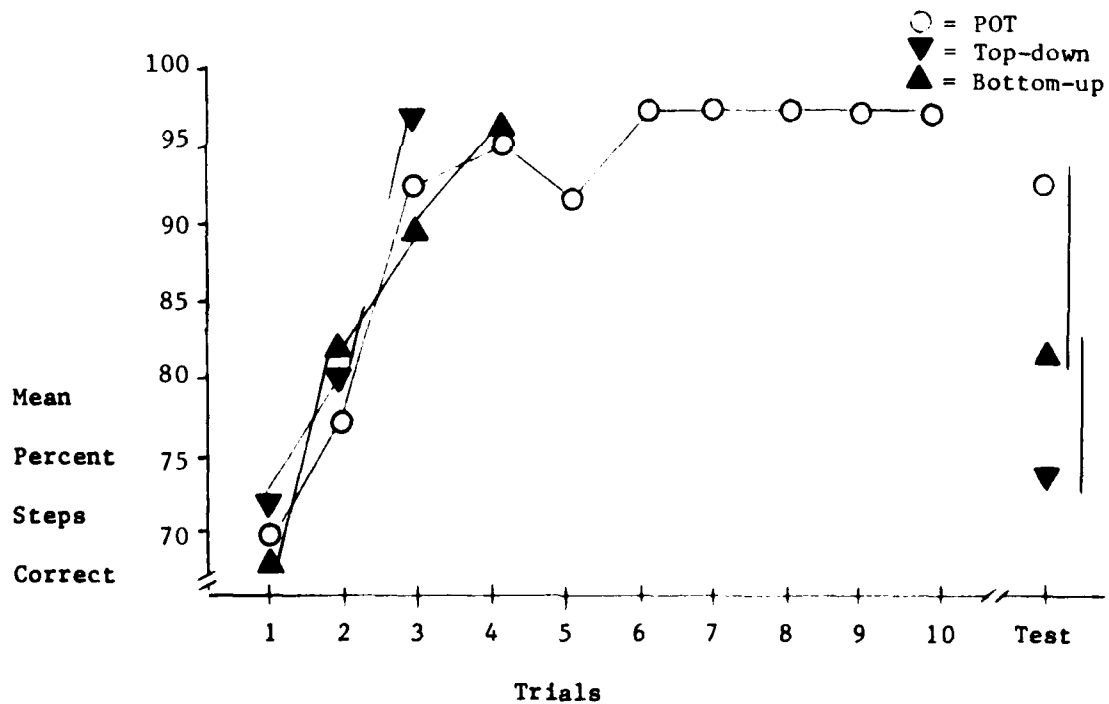


Figure 14. Trial by trial performance for responding to an engine compartment fire.

hierarchical cluster trees, presented in the Appendix as Figures 15 through 26.

Task steps are listed along the horizontal axis of each figure with the relative spacing of the steps corresponding to the median time intervals between adjacent steps. Horizontal lines in the figures indicate the cluster units and the maximum time interval between members of each cluster. For example, in the far right side of Figure 15, the last two steps ("place in fire" and "ride handle") were joined with the time between them being three seconds. The two preceding steps were joined with the time between them being second. Those two clusters were then joined with the maximum time interval (between "lower feed tray" and "ride handle") being nine seconds.

Structure results for clearing the M240 (Figures 15, 16, and 17) are nearly identical for the three training strategies. Each structure has three major clusters. The first two steps ("place in fire" and "charge") form the first cluster. The second major cluster is made of two subclusters. The first of these subclusters contains three steps ("place in safe", "open cover", and "check for ammo belt"). The formation of this cluster represents the only variation between the three structures. For the bottom-up and POT students, these steps were joined together in one step of the analysis because the adjacent steps were tied at three seconds apart. For the top-down structure, "open cover" and "check" were joined first, then followed by "place in safe" several iterations later in the analysis. The second subcluster contained "lift feed tray" and "look and feel." The third and last major cluster for each structure also contained two subclusters. The first was made up of "lower feed tray" and "close cover", and the other contained "place in fire" and "ride handle."

Dashed, vertical lines in the figures represent boundaries between the clusters of steps as they were presented in top-down and bottom-up training. That is, the top-down and bottom-up training programs presented the first four steps as a cluster, with the next three steps as a second cluster, and the last four steps as the last cluster. The shorter dashed lines represent subcluster boundaries in the training structure. Differences at the cluster and subcluster levels between training structures and obtained empirically derived structures are indicated by the dashed lines intersecting the horizontal structure lines.

For the radio task (Figures 18, 19, and 20), there are numerous inconsistencies among the structures obtained for students in the three training programs and between these structures and the training structure. For example, there are three major clusters identifiable in each of the empirically derived structures, however the steps in each of these clusters vary across the training groups. The training structure also had three major clusters. The last training structure cluster (dealing with radio transmitter controls) is captured by two groups (top-down and bottom-up). The other two training structure clusters are not apparent in any of the groups. One reason for the variation in the boundary of the first two clusters is the frequency with which students distinctly separated verbalization of connecting the left and the right audio cables, coupled with time taken to explain how to connect the cables. This had not been included in the training structure, but of course was included in the training instructions.

For adjusting the M2 headspace, students frequently omitted a series of steps which were infrequently practiced because of the nature of the checking sequence for adjusting the headspace. Because of this, a rule was adopted to include in the cluster analysis only those steps elicited by at least 50 percent of the students. Except for steps omitted by this rule, the cluster results for top-down and POT students (Figures 21 and 23) are very similar and quite like the training structure. Both of these training groups exhibited structures composed of two major clusters. The structure for the bottom-up students (Figure 22) appeared as three major clusters and consequently, was unlike the structure for the other groups and unlike the training structure. The subclusters matched the training structure subcluster; the differences were in the way the subclusters were joined together.

Finally, empirical structures for responding to an engine compartment fire for bottom-up and POT trained students (Figures 26 and 27) are similar to the training structure. That is, the four major clusters presented in training are clearly identified by the analyses. The top down result (Figure 25) diverges from the others in that steps from the second and the fourth training clusters are identified as parts of the top-down third clusters.

## DISCUSSION

The purpose of this research was to examine two variations (top-down and bottom-up) of a training strategy for presenting task information to students. It was anticipated that this strategy would facilitate the efforts of these students to encode and organize that information in their memories. Based on the theoretical perspective that memory is organized by clusters of related units of information, the hypothesis was adopted from Morrison (1982) that students can be assisted in their memory organization efforts and that the resulting memory organization would enhance learning and retention by enabling the students to remember the steps as clusters rather than as separate entities. The pattern of results clearly do not support the hypothesis. However, the results are replete with training strategy by task interactions which make their interpretation and generalization to other tasks more difficult. Therefore, results from each of the four tasks are discussed separately below.

For the M240 task, which was the simplest to perform since it was comprised of only eleven linear steps, the training strategy had no apparent effect on either acquisition of the task during practice or recall (either performance or verbal) of the task two days later. All three groups performed at near perfect performance.

For the radio task, which can be considered slightly more difficult since it was comprised of nineteen linear steps, one of the two training strategy variations, the top-down strategy, was found to have an effect opposite to that expected. Presenting information to students using the top-down approach reduced the level of task proficiency reached at the end of the practice period instead of increasing it. This result could have been caused by the fact that students in the top-down conditions had fewer

practice trials in the top-down condition than in the bottom-up or POT condition. Of particular importance, however, was the additional finding that there was no difference between the groups in performance or verbal recall when measured two days later. Since the students in the top-down conditions showed lower levels of proficiency at the end of practice (see Figure 10), this suggests that students in the top-down condition may have forgotten less of what they had learned than students in either the bottom-up or POT conditions.

Just the opposite pattern of results was obtained for the M2 task which can be considered to be more difficult than either of the previous tasks since it was comprised of nonlinear steps. While there were no apparent training strategy effects on task acquisition, there were significant differences in delayed performance and verbal recall. The performance and verbal recall of the students in the top-down condition was significantly lower than that of the students in the bottom-up and POT conditions when measured two days later. Thus, there seemed to be a greater decrement in performance between the practice and test periods for the top-down students than for the other students (see Figure 13). The difference between top-down and POT conditions can be explained by practice and overlearning. That is, top-down students practiced just enough to reach the same plateau as POT students. However, the overlearning achieved by the extra practice for POT students led to increased retention compared to the top-down students.

A number of observations can be made concerning these results. First, it seems that one of the assumptions underlying this research is incorrect, at least for the tasks trained. That is, it was initially assumed that students would not be sufficiently adept at mentally organizing task steps to efficiently learn the tasks in the limited time given them. Mean performance levels on the first practice trials of students in the POT and bottom-up conditions negate that assumption. In the memory organization literature it is nearly axiomatic that working or short-term memory is limited to five to seven units of information and that greater performance capacity can only be achieved by cognitively organizing information. In order for students to have performed the tasks in this study without assistance or prompting, some memory organization must have taken place. For the M240, radio and M2 tasks, first trial performance for POT and bottom-up students was approximately 95 percent. Thus, these students must have cognitively organized much of the task without assistance after only minimal presentation of task steps and with only one guided practice trial. If students had already organized most of the task information with such limited introduction, the training strategy of providing task organizing information could not contribute greatly to the learning process. In a similar vein, Gagne and Dick (1982) have argued that learning strategies have been effective in past research because they were applied to essentially meaningless tasks (e.g., word lists) making meaningful organization possible. They further suggested that for inherently meaningful tasks, and those in the present research were meaningful, strategies for learning may have less utility. This appears to have been the case for these tasks. Given that initial, unassisted performance was so high, the addition of structure information had little room to improve performance.

Initial performance on the engine compartment fire task was not as good as the other tasks (approximately 75 percent correct) suggesting that

it was more difficult for the students to encode. Therefore the task organization information might have had a greater chance to facilitate learning. Yet, it did not. Furthermore, when the additional information was presented early, as in the case of the top-down strategy, terminal learning level seems to have been reduced, although this may be attributable to the reduction in practice trials rather than any direct interference between the structure presentation and learning. Therefore, regardless of the task, the structure information that was added to the basic POT training strategy had no effect other than reducing the amount of time available for practice. Within fixed time constraints, the addition of a task structure presentation was not more effective than POT.

#### Students' Task Organization

Although the rote training strategy of POT functioned as well or better than the structure training strategies, this is not to say that students did not structure the task. Rather that they did not rely on the information presented. Further evidence of the ability of students to extract the structure from a meaningful task comes from the cluster results, particularly for the POT students who received no structure information in training. That is, the analyses of the verbal recall protocols of POT students yielded the same task structure as presented in training to the top-down and bottom-up students for both the M2 and engine compartment fire tasks.

For the M240 task, empirically derived structure for the POT students did not match the training structure, but it did match the empirically derived structures for both top-down and bottom-up students. The mismatch between the structures derived by the top-down and bottom-up students with the training structure was unexpected since the training structure was developed from the empirical analysis of verbal recall protocols of another sample of soldiers (Morrison, 1982). These soldiers, however, had received more extensive training with the M240, including performance of a variety of other tasks related to the task used in the present research. Perhaps this difference in experience with the M240 created differences in perspective on the relationships among task steps resulting in different structures. Memory organization has generally been assumed to be a developmental process in which structures evolve from one organization to another in order to gain storage and recall efficiency (Glaser, 1982; Gilmartin, et al, 1975; Pellegrino & Ingram, 1979; Schvaneveldt, et al, 1982). If so, the difference between the structures may have been due to this developmental process, part of which may be due to reinterpretation of the task based on an expanded context for the more experienced soldiers. Regardless of what created the differences between the Morrison (1982) analysis and the current analysis, the structure derived from the POT students were no different from those derived from the top-down and bottom-up students, confirming the ability of the students to structure the task without specific assistance in doing so. Clustering seemed dictated more by the characteristics of the task itself than by the verbal/pictorial presentation of a structure for the task.

For the radio task, all three group structures were different and none matched the training structure. These differences between group recall

patterns probably also indicates that there was variation among individuals within each group. Several reasons for this inconsistency can be suggested. First, since the radio components used for practice were all laid side by side on a table, the spatial orientation, which appeared in Morrison's (1982) empirical analysis and was used in the structure presented in training, was much less obvious than in an actual tank. In addition, students were not told what each specific step accomplished, and these accomplishments were not obvious (e.g., there were two volume controls, and two power switches; in neither case were they adjusted to the same position). These two factors may have reduced the inherent meaningfulness of the task leading to more subjective (Tulving, 1982) and idiosyncratic task organizations. In addition, instruction necessarily included information concerning how to do several of the steps as well as what to do, even though this information was not coded in the training structure. Frequently, students included this "how to" information in their task descriptions. These interjections were not coded in the analysis and may have reduced the representativeness of the group structures.

Thus the evidence appears to suggest that, contrary to expectation, students begin to structure a task immediately. Furthermore, given the several inconsistencies between students' structures and training structures, the structuring process may be driven more by students' direct involvement (listening, watching the demonstrator, and performing the task) than by the abstract presentation of structures. Resnick (1976), who advocates the use of task analysis procedures to uncover the cognitive structure of tasks, has hypothesized that students tend to use whatever is given as just the starting place from which to conduct their own analyses and make their own discoveries. The students in this study may have been more inclined to use their own experience rather than to accept the verbal presentation. On the other hand, the students who had just spent eight weeks learning various basic soldiering tasks by POT, may not have understood how they were supposed to have used the task structure information, and therefore ignored it.

The fact that the students' M2 and fire task structures derived from student responses closely duplicated the training structure may be the results of students independently arriving at the same point rather than their structure being guided by the presentations. It is interesting that this concurrence between students' and training structures occurred for the rationally developed training structures rather than the empirically developed ones. This may have been the result of the task analysts (the researchers) and the students acting from the same perspective. That is, while the analysts were very familiar with the tasks per se, they were less familiar with other associated tasks and thus more closely shared the perspective of the novice students than did the more experienced soldiers on which the M240 and radio task structures were based. Montague (1982) has argued that task analysis must be accompanied by student analysis in order to understand the perspective of the student. This argument is not meant to negate the Gestalt assumption adopted earlier that individuals may share a common memory organization because of the inherent structures of the task. Rather it is meant to qualify that statement to say that individuals who share a common perspective and background may share a common memory organization because of the way they view the inherent structure of the task.

## Role of Practice

The results also suggested that practice was the primary determinant of performance. The role of practice in determining both performance level and memory organization reflects the theoretical perspectives of Fitts (1964) and Anderson (1976, 1982) concerning the acquisition of procedural tasks. Although Anderson's theory was developed to apply to much more complex cognitive procedures than represented by the relatively simple tasks examined in this research, it is based on a general premise that the mental organization that controls proficient performance of procedural skills can only be acquired by practicing those skills. The premise applies to the full range of procedural skills from those which seem to be primarily motor in nature (e.g. driving a car) to highly complex cognitive skills (e.g. using language). Furthermore, the verbal control of procedural performance diminishes even to the point at which the ability to verbally describe how to do the task may disappear. Since the hypothesis of the present research was that providing task structure information verbally could facilitate the cognitive organizing process, one could argue that the approach presents too much verbal information. On the other hand, the acquisition of a procedural skill, in the training context, begins as a verbally mediated process (Anderson, 1976, 1982; Fitts, 1964). The relevant questions for instruction then concern the type and amount of verbal information. For the tasks and students used in this research, practice apparently facilitated learning more than verbal structure presentation. It is interesting that for the two tasks where training strategy differences appeared, the extra practice of the POT students led to better verbal recall as well as better hands-on performance.

One final piece of evidence for the ineffectiveness of the structure presentation was the anecdotal observation of subject resistance to the instruction to say out loud the names of the task clusters while they practiced the task. Students needed frequent prompting, but often performed the task steps so rapidly that prompting at the appropriate time was difficult. The number of students who complied with the instruction to use the cluster names was so small as to be a point of discussion among the instructors for each of the tasks. Since this resistance was unexpected, no systematic observation of this phenomenon was documented.

## Summary and Conclusion

The hypothesis of the present research was that providing task structure information could facilitate the cognitive organizing processes that occurs during learning by giving students a cognitive orientation from which to begin their organization. This hypothesis was not supported. For three of the four tasks trained, students initial, unaided performance was so high as to almost preclude the facilitating effects of any additional verbal information. For the fourth task, performance appeared to be a function of practice differences between the training strategies. Given acceptance of the cognitive, information-processing theoretic basis of this research, for learning to occur one must assume some kind of cognitive organization must also occur. Thus, the goal of instruction is to support these memory organizing efforts. Although the relatively simple, straightforward approach offered by the task clustering strategy did not facilitate

performance for the tasks examined, efforts to design training strategies that would facilitate cognitive organization by students (e.g., Brown, 1978; Glaser, 1982; Greene, 1978; Montague, 1982; Resnick, 1976; Thorndike, 1981) should not yet be abandoned. On the other hand, these efforts also need to consider the issue of how much can be done for the students and how much they must do on their own. This issue seems particularly important in light of the capability for new training equipment technologies which offer tremendous opportunities for automation and individualization instruction. The ability to deliver massive quantities of information, pictures, graphics, text and sound, all automatically controlled by interactive computer-based programs does not mean that massive quantities of information is what is always needed. Perhaps the focus should be on the interactive capabilities of this equipment with much less attention given to the equipment's role in the interaction and much more attention given to the needs of the student (Montague, 1982). We may find that there are times when it is best to let the students struggle on their own rather than providing an immediate interruption with more information to process when their cognitive processing is already strained.

This research offers a basis for continued investigation of the application of cognitive, information processing theory to training. In particular, two issues were identified which call for refinement in the approach. First, greater attention should be given to the selection of tasks for which providing assistance in the organization of task steps would be fruitful. For example, tasks which lack inherent meaningfulness (e.g., some computerized tasks where it may be unclear what each operator action accomplishes) or very long tasks which may make the meaningfulness difficult to detect. Second greater attention should be given to the perspective of the student, and the type and amount of information they need and when (e.g., structure information presentation and practice may be interspersed). Without these refinements, POT with its emphasis on practice appears to be the most efficient strategy.

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APPENDIX  
Empirical Structure Results

# M240 TOP-DOWN

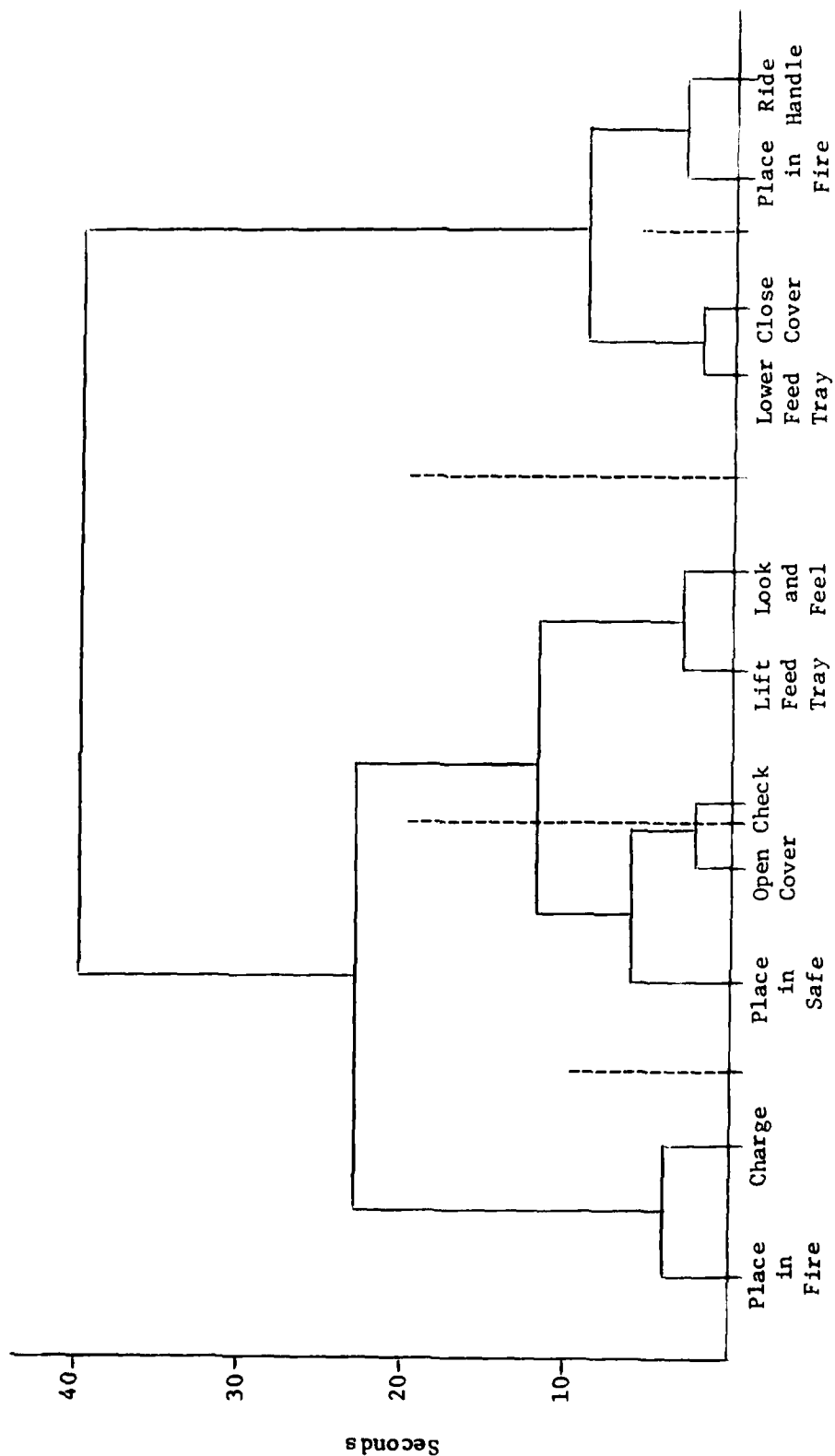


Figure 15. Structure analysis for clear the M240--Top-down students.

# M240 BOTTOM-UP

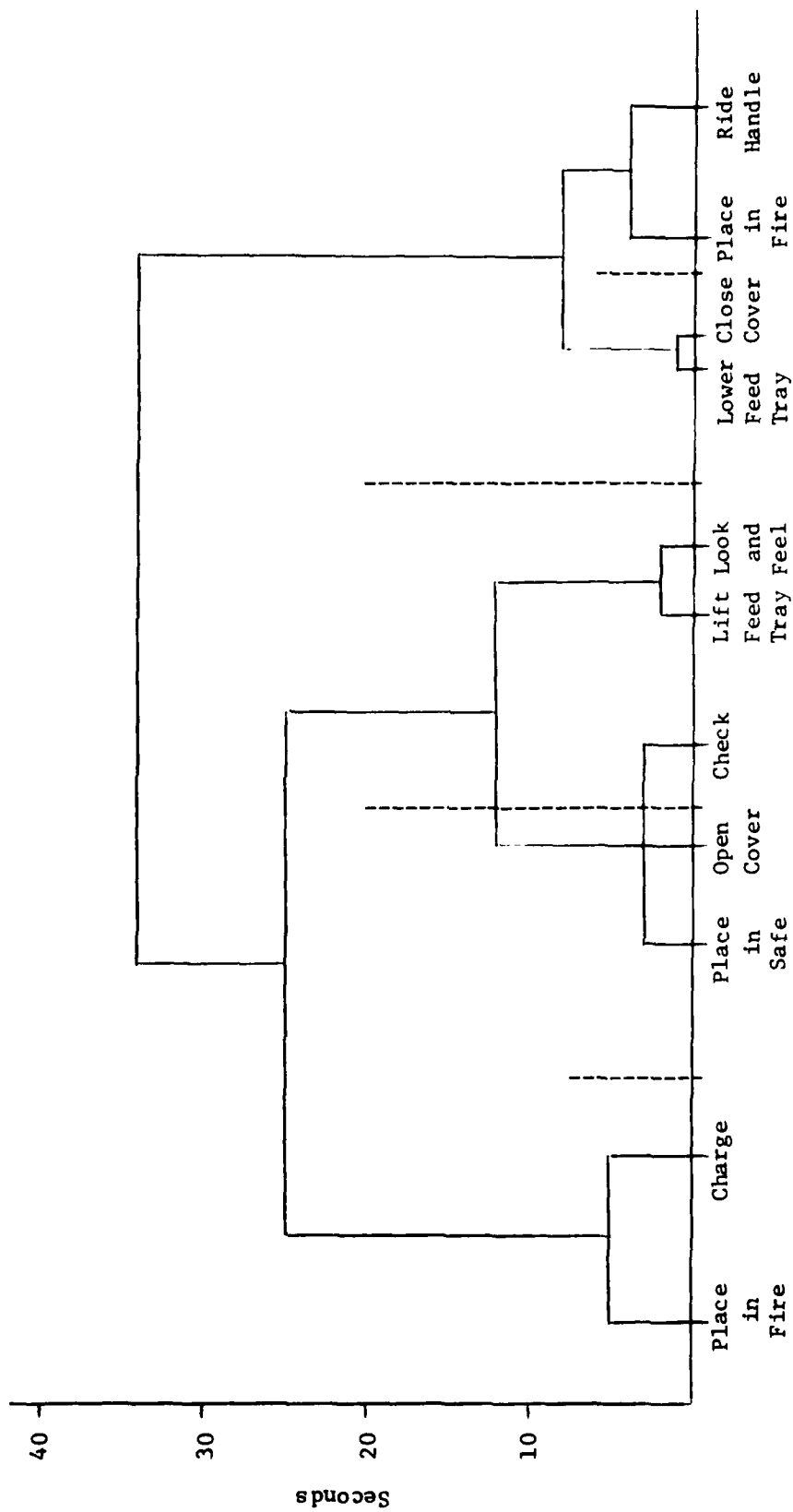


Figure 16. Structure analysis for clear the M240--Bottom-up students.

# M240 POT

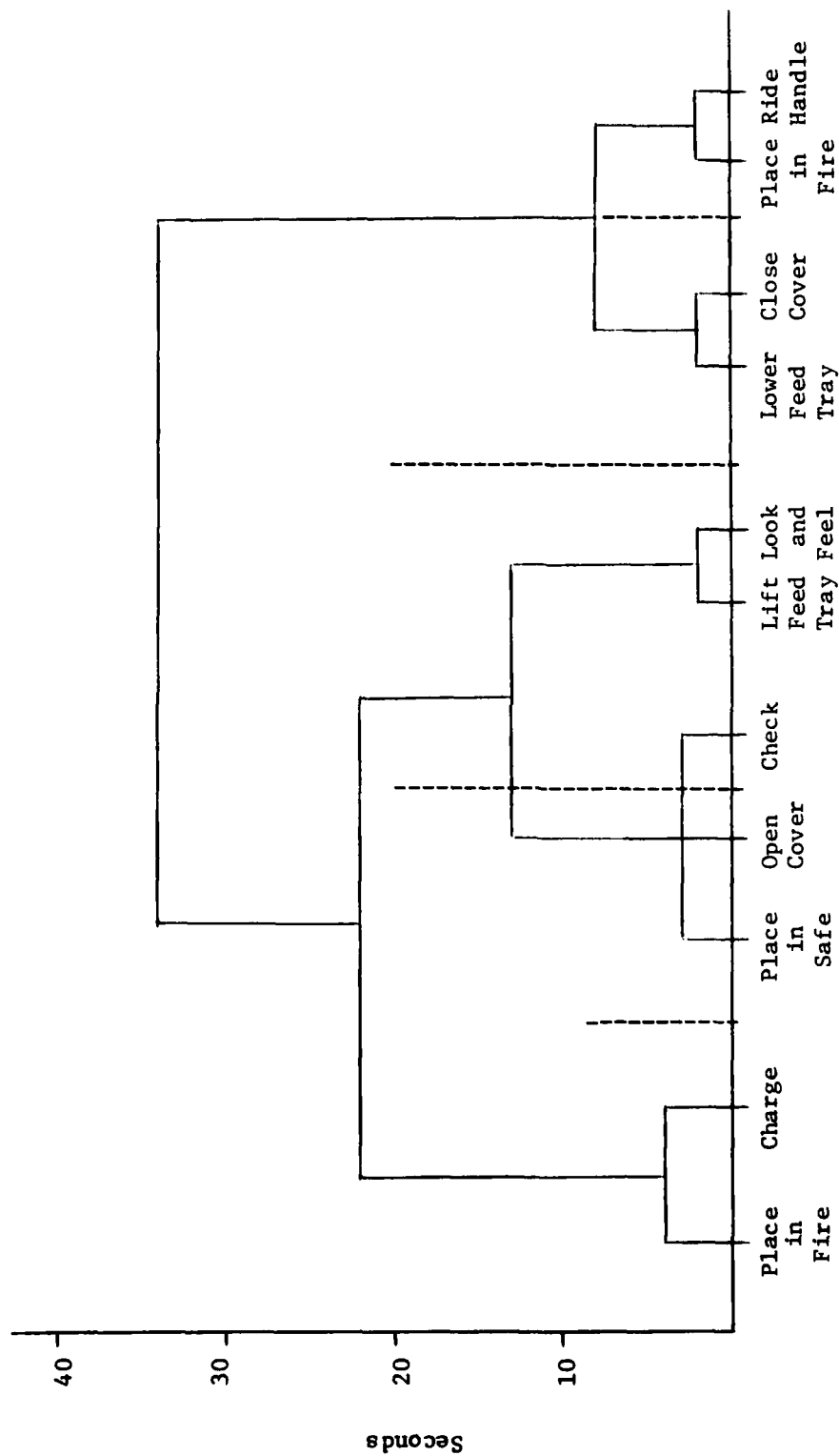


Figure 17. Structure analysis for clear the M240--POT students.

# OPERATE THE RADIO--TOP-DOWN

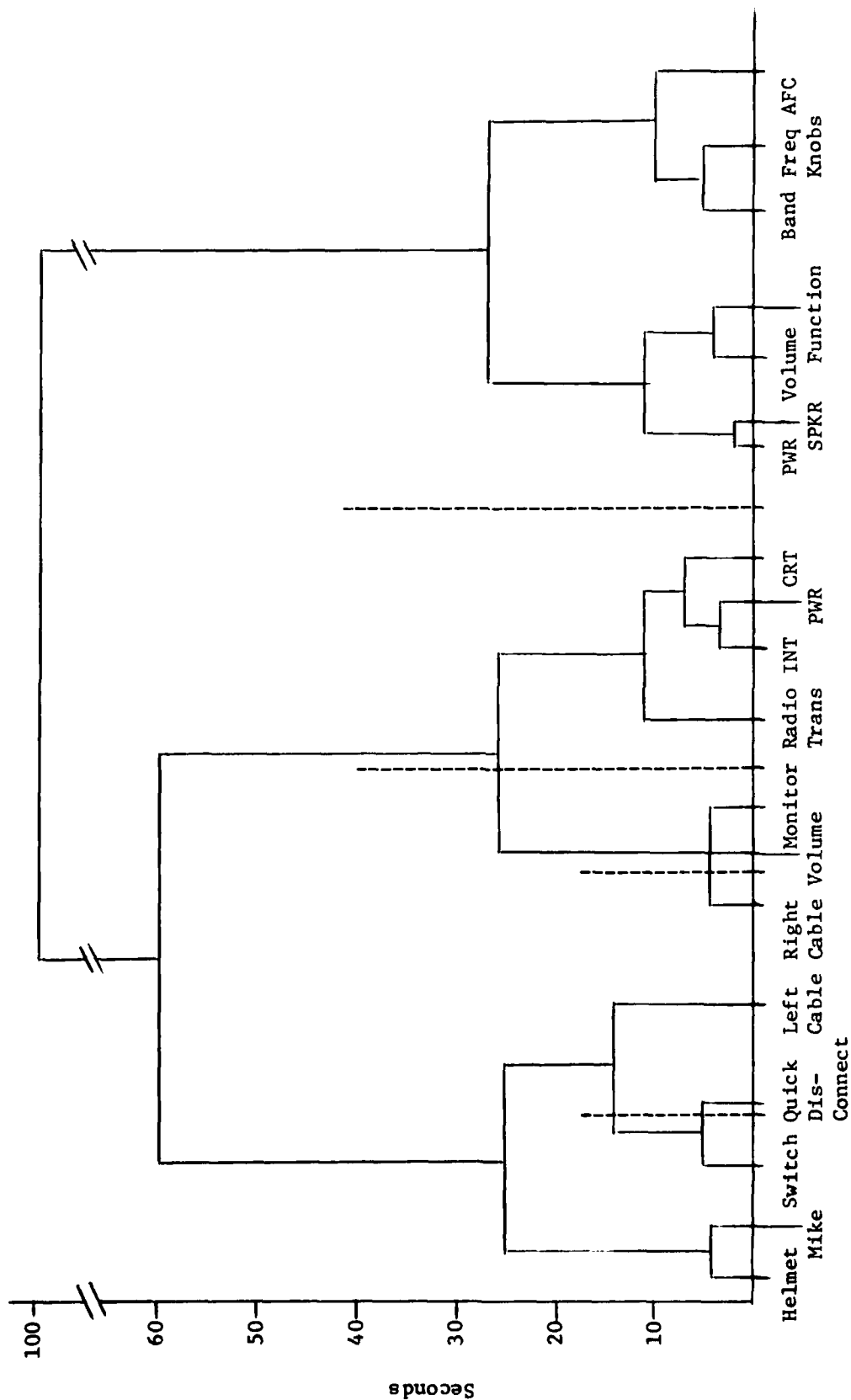


Figure 18. Structure analysis for operating the radio--Top-down students.

# OPERATE THE RADIO BOTTOM-UP

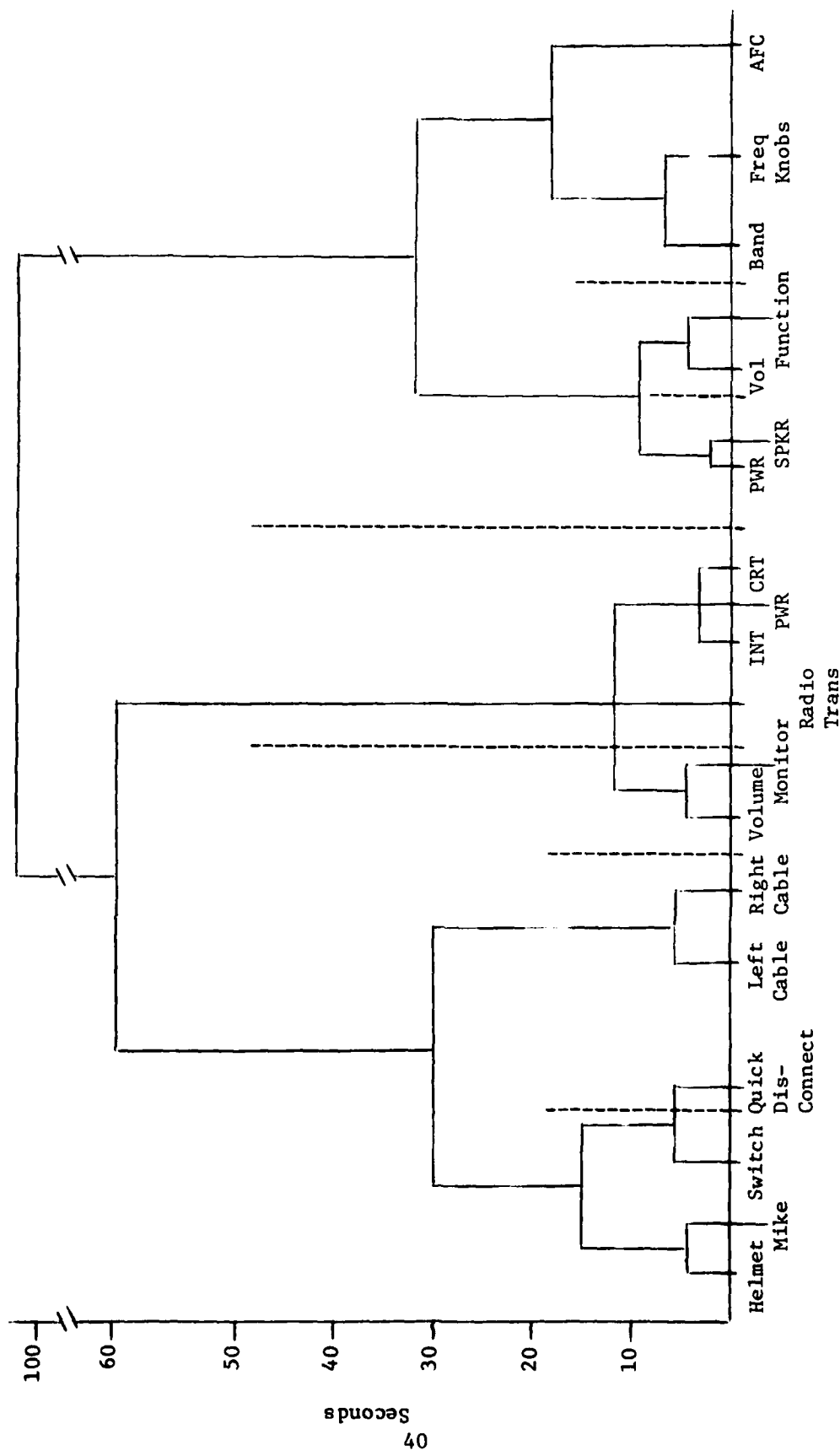


Figure 19. Structure analysis for operating the radio--Bottom-up students.

# OPERATE THE RADIO-POT

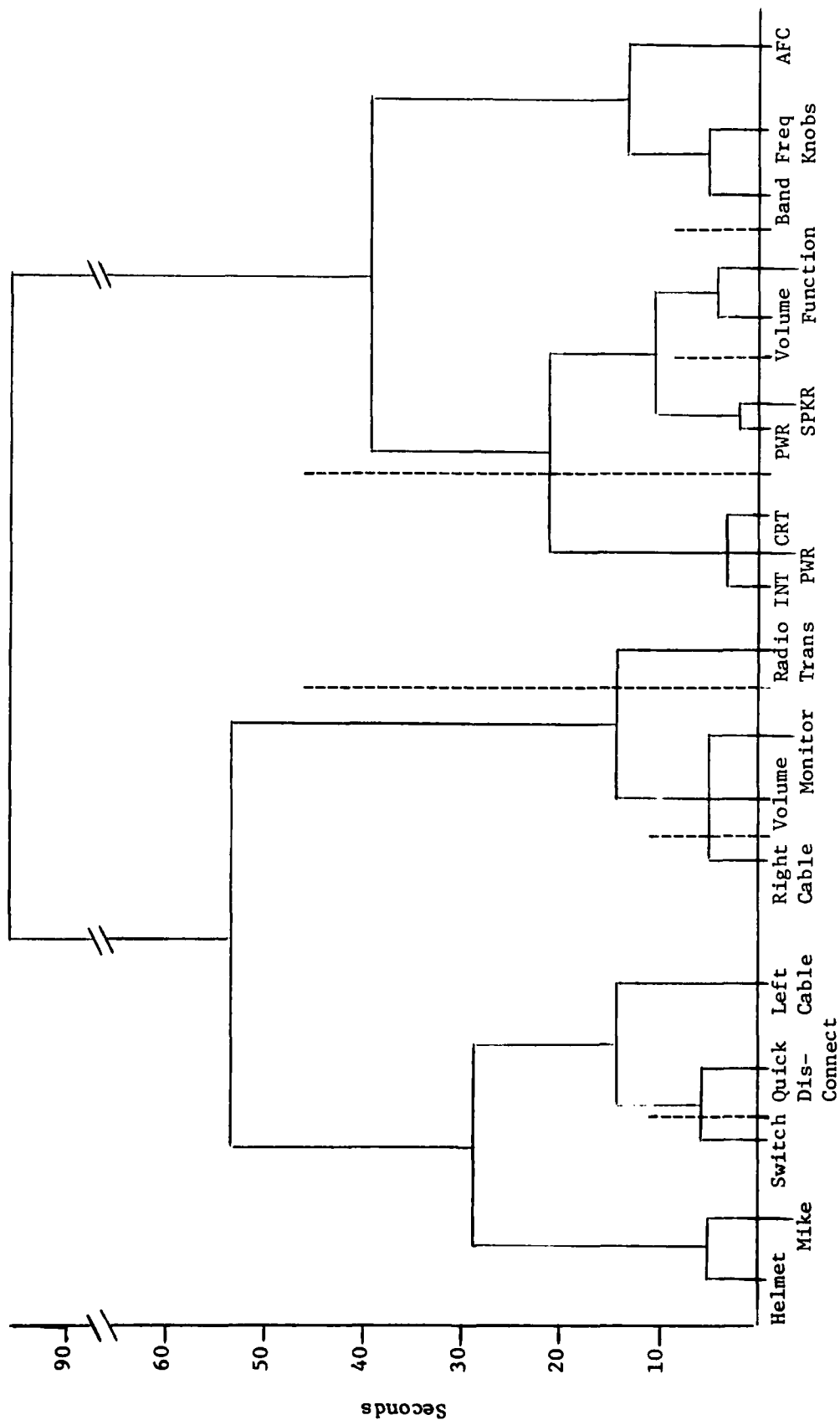


Figure 20. Structure analysis for operating the radio--POT students.

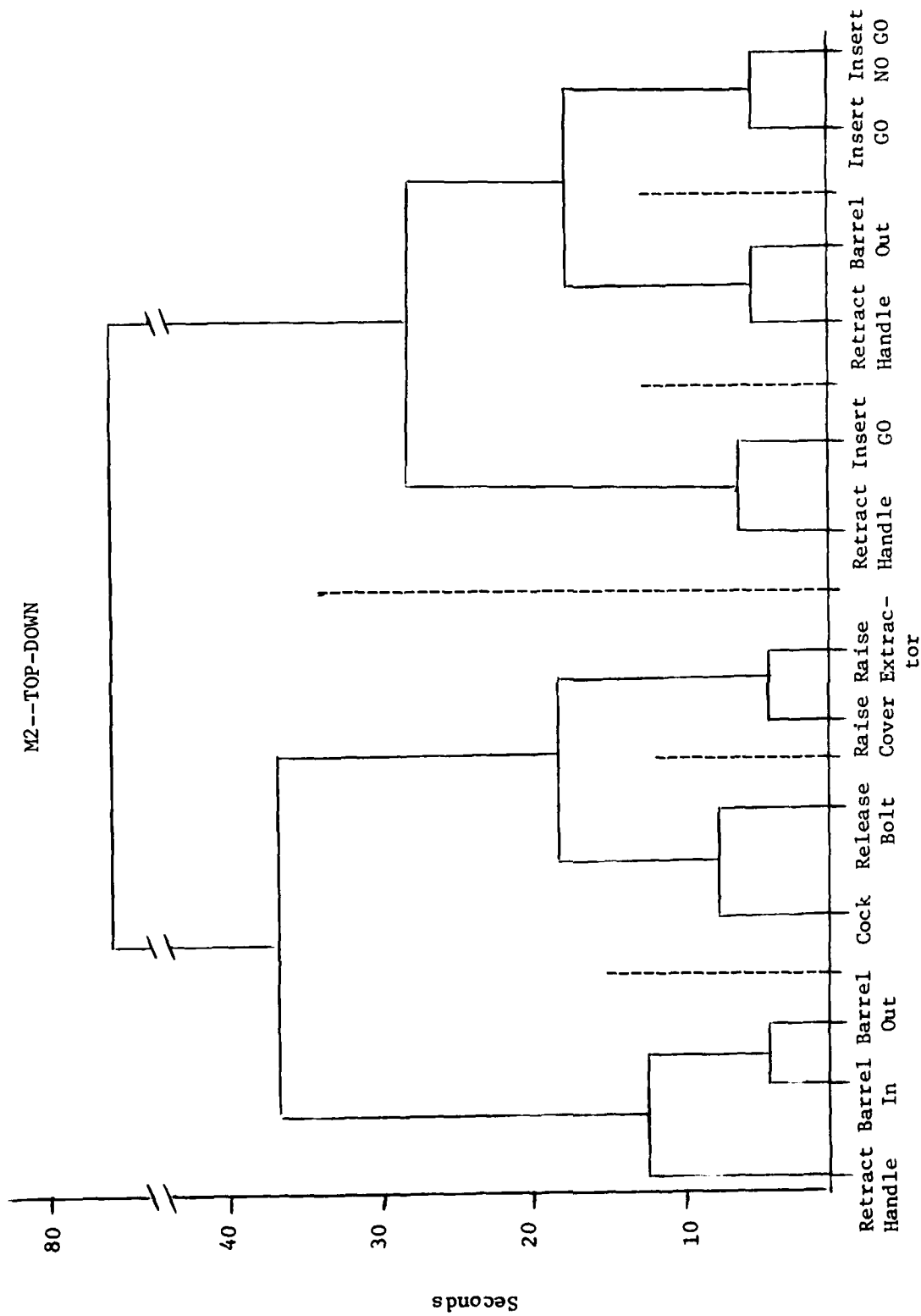


Figure 21. Structure analysis for adjusting the M2 headspace--Top-down students.

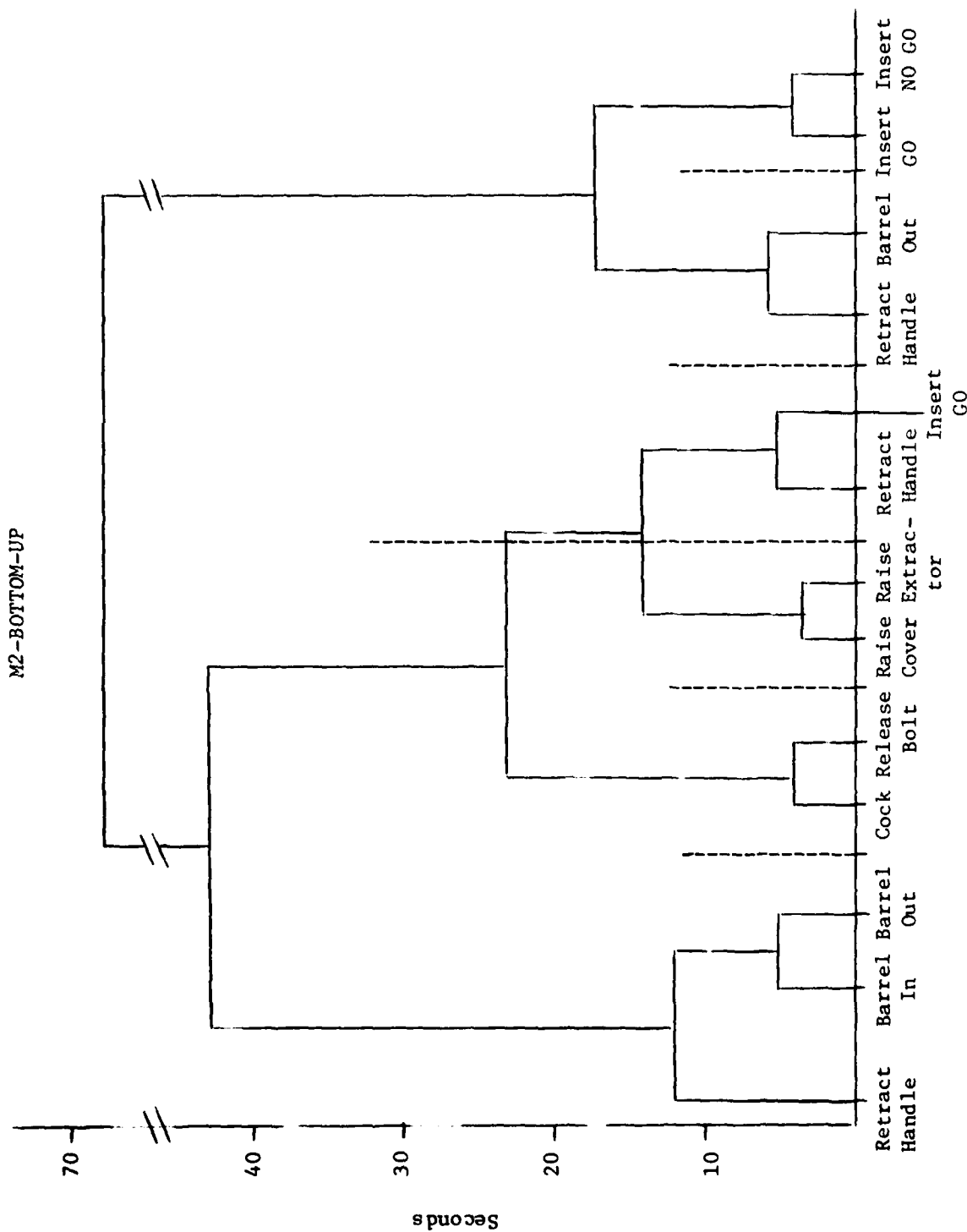


Figure 22. Structure analysis for adjusting the M2 headspace--  
Bottom-up students.

M2--POT

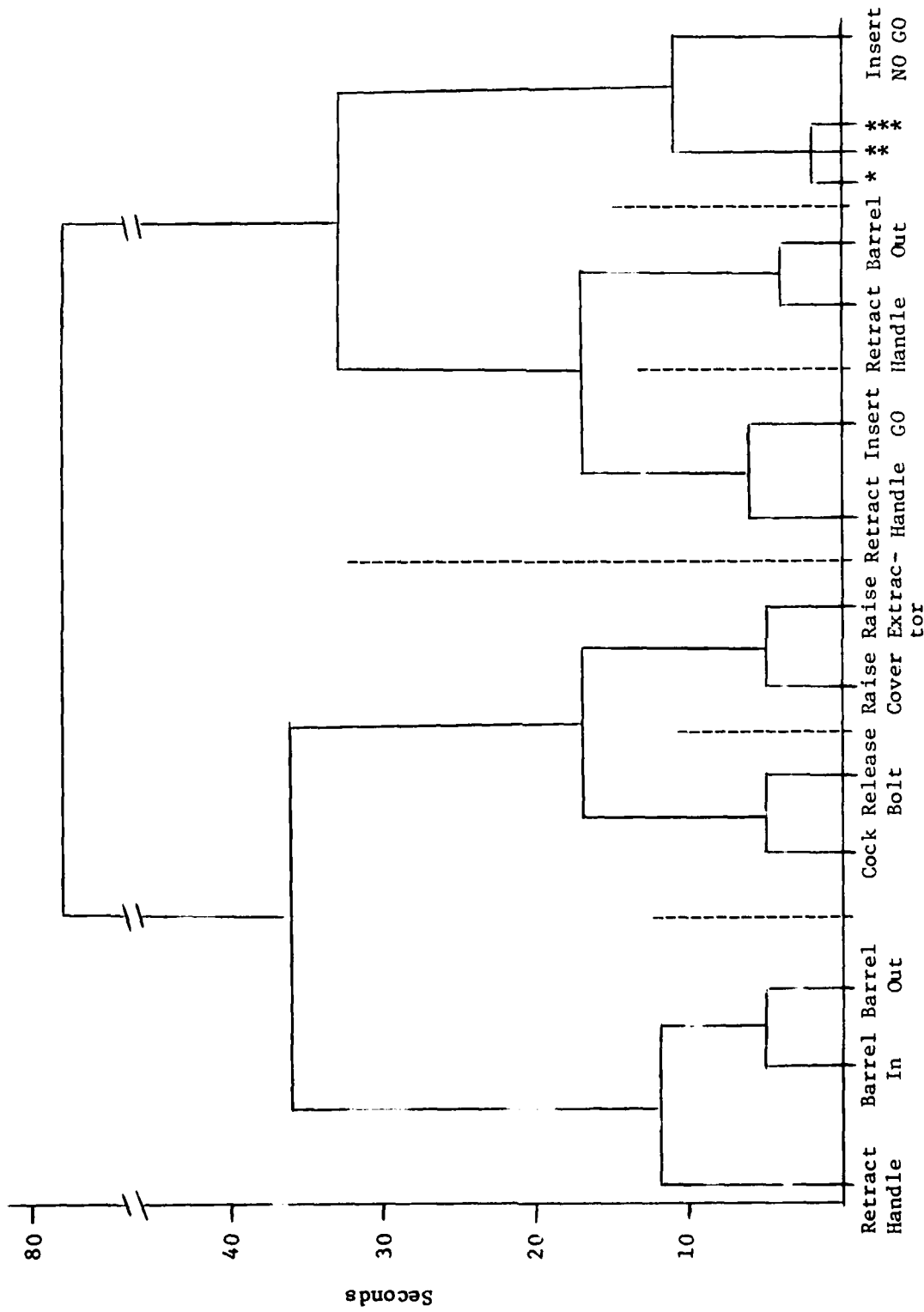


Figure 23. Structure analysis for adjusting the M2 headspace--POT students.

\* = Release Handle

\*\* = Retract Handle

\*\*\* = Insert GO

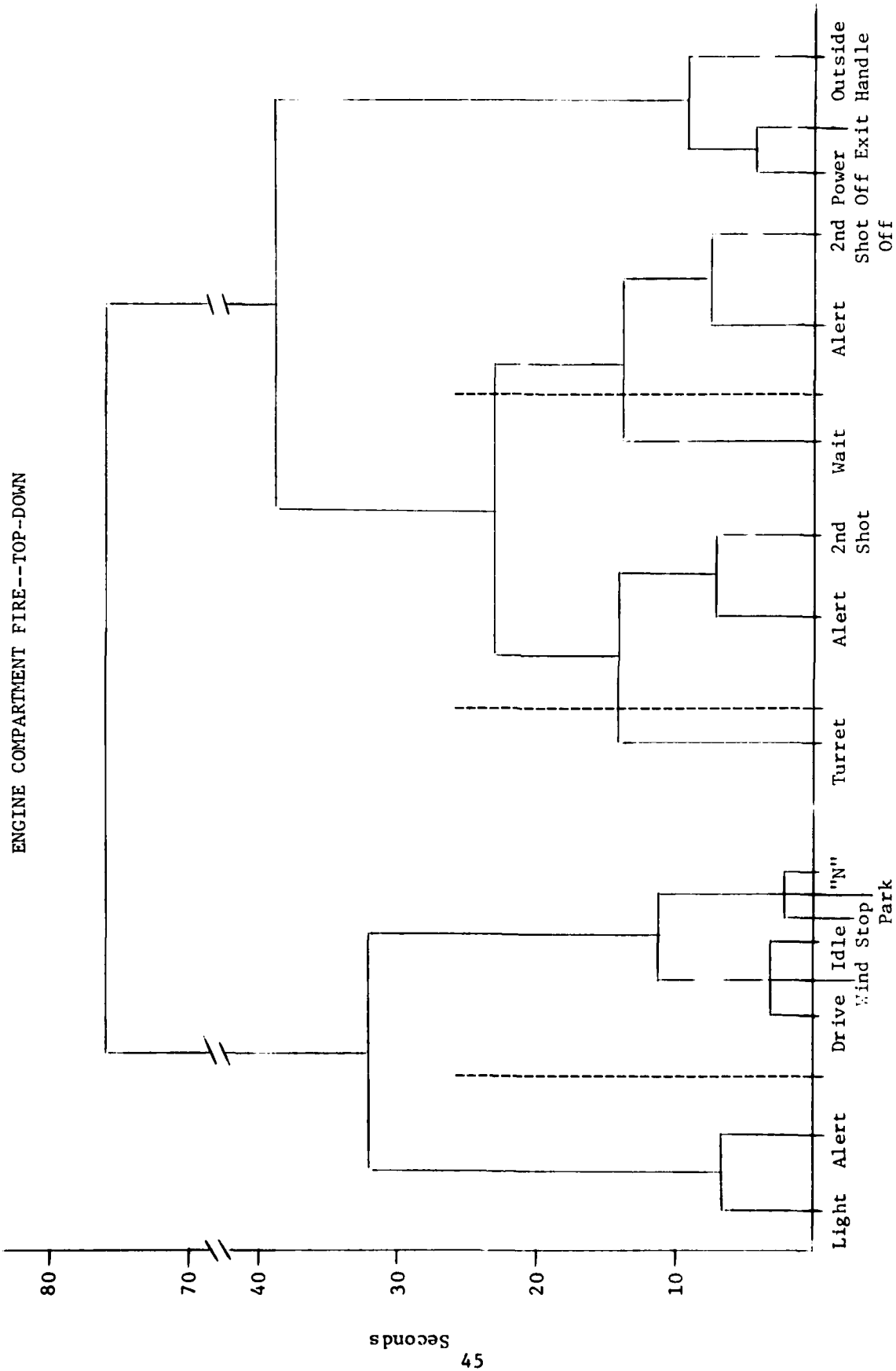


Figure 24. Structure for responding to an engine compartment fire--  
Top-down students.

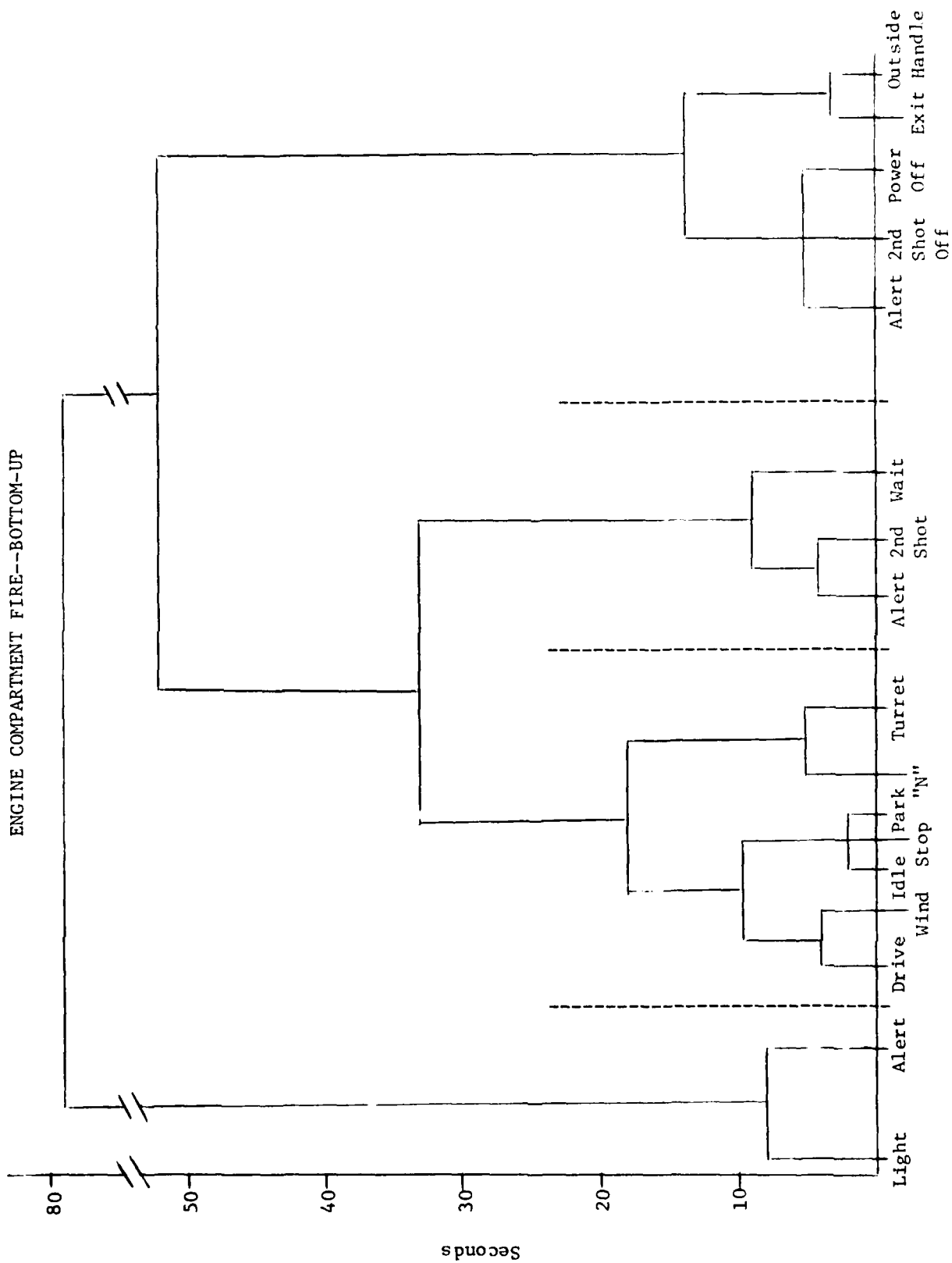


Figure 25. Structure analysis for responding to an engine compartment fire--  
Bottom-up students.

# ENGINE COMPARTMENT FIRE--POT

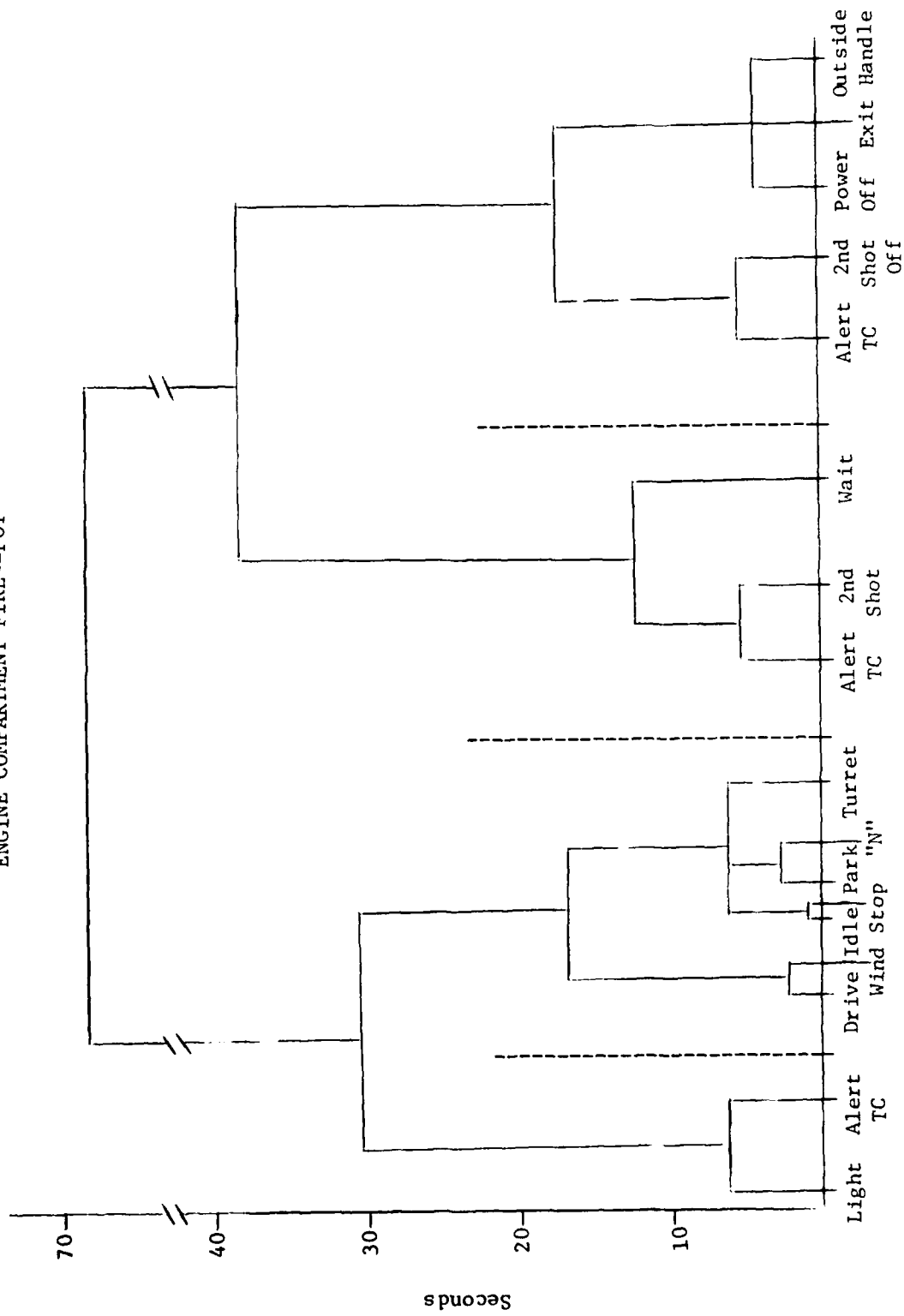


Figure 26. Structure analysis for responding to an engine compartment fire-- POT students.